Stewardship means to protect and grow

Public Comment for The Delta Stewardship Committee 28 April, 2017

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The Tunnels will degrade the water quality of the Delta, this has been shown in study after study.

Water is sent south for agriculture in greater and greater amounts every year.

This month I drove I-5 down the valley from Stockton to Bakersfield and back up 99 with crossovers between.

The southern section of the California Aqueduct appears to be at capacity as of Thursday 27 April 2017.

Saw much land once in annual crops 20 or more years ago is now in permanent water thirsty crops.

Saw a few thousand acres now covered with dead trees, presumably because of poor water rights and a poor economy.

Those folks with poor or junior water rights are screaming through roadside signs that the drought and lack of water has been political and artificially contrived.

To be a good steward of a limited resource one must insure that a scarce resource is wisely used.

Huge amounts of the plantings of Nut Trees have replaced cotton and tomatoes over the last 25 years

Depending on the crops involved the water difference can be 25% or 50% more to twice as much for some tree crops. Trees are a crop that will need that level of water for 30 to 50 years. Cotton, tomatoes and such are annual crops that need to be chosen at most a year before planting and often only 6 months ahead.

I recommend that the Delta Stewardship Council work with CARB, DWR and other agencies to realize a plan for crop management. It may be too late for those acres now in trees, but a lottery system can be used going forward to manage an allotted amount based on land coming off of permanent production. The amount of acreage allotted for the permanent crops should be based fully on water rights and a sliding percentage of acres managed.

I can't say for certain, but based on the permanent crops I have seen planted on the west side of the San Joaquin valley over the last 40 years, agriculture has likely increased water demands by 30 to 50 percent, mostly offset by reduced use through better water management practices that have been adopted for other crops.

To declare that an additional conveyance, currently the Delta Tunnels, would be a significant deviation from the concept of stewardship, which is protection and management. By proposing AND promoting the Delta Tunnels there is a major conflict of interest. Like any organization that creates rules, polices those rules and operates or develops something covered by those rules, conflicts will occur.

Having what will be a vested interest in the existence of the Delta Tunnels while controlling them?

There is less evidence that the Delta Stewardship council is independent and impartial with each step forward.

Per a 1985 UC Davis evaluation 40 or more inches of water, 3.5 feet, is needed for Pistachios
REF: Cal Pist Ind.1985 Ann Rpt.85-92.pdf

Likewise Almonds needs for water are over 40 inches, 3.5 feet
This is 2 to 4 times as much water as olives, stone fruits like peaches, plums or cherries and citrus
REF:
http://ucmanagedrought.ucdavis.edu/Agriculture/Crop_Irrigation_Strategies/Almonds/

Cotton typically uses less than 30 inches of water and is an annual crop.
REF:
https://coststudyfiles.ucdavis.edu/uploads/cs_public/c7/c3/c7c30ec5-2b2c-4692-86a7-f8f47736202d/cotton30sjv03.pdf

Tomatoes for the fresh market use about 36 inches of water
https://coststudyfiles.ucdavis.edu/uploads/cs_public/2e/2a/2e2a411e-73e1-469c-9eae-8458c3badedf/tomatofrmktsj07.pdf

Tomatoes for processing into canned products use about 30 inches of water http://ucmanagedrought.ucdavis.edu/Agriculture/Crop_Irrigation_Strategies/Processing_Tomatoes/

University of California
UC Drought Management

Processing Tomatoes

Coping with Drought: Strategies for Irrigating Processing Tomatoes

Introduction

Much of the US processing tomato production is in California with most of the production occurring in the San Joaquin Valley. Furrow irrigation was commonly used for tomato production in the past. Currently, subsurface drip irrigation is the primary irrigation method in the southern San Joaquin Valley and is increasing in other California areas, but some tomato fields are still furrow irrigated in the northern San Joaquin Valley and in the Sacramento Valley.

California frequently experiences periods of drought due to limited rainfall/snow in the winter months. This can result in reduced reservoir storage, and water deliveries to agriculture can be greatly reduced. During these drought periods, tomato growers may need to implement strategies to cope with the limited water supplies. Careful consideration should be given to the potential for reducing water applied to tomatoes and the risks associated with that reduction. The bottom line however is that tomato yields can be reduced by any strategy implemented to cope with a drought.

Irrigation Water Management In a Normal Year

Irrigation water management involves determining when to irrigate and how much water to apply during an irrigation. It requires estimating the evapotranspiration or crop water use between irrigations and then applying that amount adjusted for irrigation efficiency.

Using Drip Irrigation

Drip irrigation of processing tomatoes should occur at high irrigation frequencies. Research at the University of California West Side Research and Extension Center (WSREC) showed little effect on crop yield between daily irrigations, irrigations every few days and weekly irrigations. The soil type at the WSREC is a Panoche clay loam. Actual irrigation frequencies need to be based on grower experience.

One aspect of applying the right amount of water involves estimating the ET between irrigations using the following equation and then applying that amount:

ET = Kc x ETo x IN

where ET = crop water use between irrigations, Kc is a crop coefficient, ETo is the daily CIMIS reference crop ET, and IN is the number of days between irrigations. ETo can be obtained from the CIMIS network (http://wwwcimis.water.ca.gov/cimis/data.jsp). Table 1 lists long-term average ET_o values for select location in California, and can also be used to estimate daily ET_o.

		Evapotranspiration (in/day)					
		Shafter	Five Points	Parlier	Davis	Nicolaus	Durham
Jan.	1–15	0.03	0.04	0.03	0.03	0.03	0.03
	16–31	0.05	0.05	0.04	0.05	0.04	0.05
Feb.	1–15	0.07	0.06	0.06	0.06	0.06	0.06
	16–28	0.09	0.09	0.08	0.09	0.09	0.09
Mar.	1–15	0.11	0.11	0.10	0.09	0.09	0.09
	16–31	0.14	0.15	0.13	0.14	0.12	0.12
Apr.	1–15	0.19	0.20	0.17	0.18	0.15	0.16
	16–30	0.20	0.22	0.19	0.20	0.18	0.17
May	1–15	0.24	0.26	0.22	0.23	0.21	0.21
	16–31	0.26	0.27	0.24	0.24	0.21	0.22
June	1–15	0.27	0.29	0.26	0.28	0.24	0.25
	16–30	0.28	0.30	0.27	0.29	0.26	0.28
July	1–15	0.28	0.30	0.27	0.29	0.26	0.27
	16–31	0.26	0.28	0.25	0.27	0.25	0.25
Aug.	1–15	0.25	0.28	0.24	0.26	0.24	0.24
	16–31	0.23	0.25	0.22	0.24	0.21	0.21
Sept.	1–15	0.21	0.23	0.19	0.21	0.19	0.19
	16–30	0.18	0.20	0.15	0.16	0.16	0.16
Oct.	1–15	0.16	0.17	0.13	0.16	0.13	0.14
	16–31	0.12	0.13	0.09	0.12	0.09	0.10
Nov.	1–15	0.08	0.10	0.07	0.09	0.07	0.07
	16–30	0.06	0.07	0.04	0.06	0.05	0.05
Dec.	1–15	0.05	0.05	0.03	0.05	0.03	0.04
	16–31	0.03	0.03	0.02	0.04	0.04	0.03

Table 1. Average daily reference crop evapotranspiration (ETo) in inches per day for selected locations in the Central Valley of CA.

The crop coefficient depends on the growth stage of the crop. A crop coefficient can be determined by first "eyeballing" the width of the canopy for any given day, dividing that number by the bed spacing and multiplying this value by 100 to express the coverage on a percentage basis. Figure 1, which shows the relationship between crop coefficient and canopy coverage, is then used to determine the crop coefficient. This approach is universal and can be used for any planting date.

The time required to apply a quantity of water equal to the tomato ET between irrigations depends on the flow rate of the irrigation system and the acres under irrigation. This time can be calculated by the equation

T = 449 x A x ET ÷ Q

Where T = irrigation time in hours, A = acres being irrigated, ET is the evapotranspiration between irrigations in inches, and Q = irrigation system flow rate in gallons per minute.

Using Furrow Irrigation

It is difficult, if not impossible, to measure the parameters involved in efficient management of furrow irrigation systems. These parameters include water infiltration rates, flow rates in earth-lined ditches, root depths, and allowable soil moisture depletions. Thus, managing furrow irrigation is more of an art than a science and is usually based on grower experience. However, easy to use methods of monitoring soil moisture such as soil probes or Watermark soil moisture sensors might be used to detect any management problems such as excessive intervals between irrigations or excessive amounts of applied water. Surface runoff should be recovered and recirculated on the field being irrigation or used elsewhere on the farm if possible.

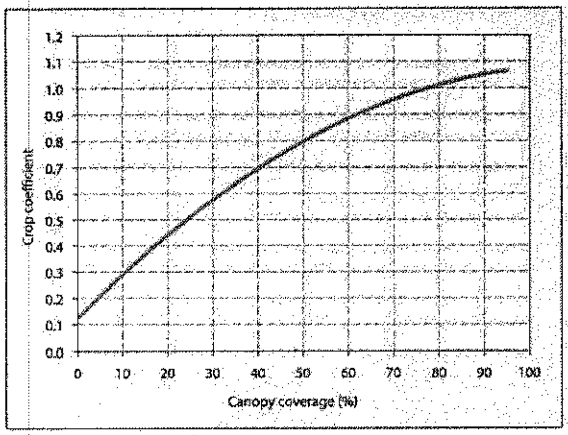

Figure 1. Crop coefficients based on canopy cover. Canopy cover is expressed as the percentage of the soil surface shaded by the canopy at midday.

Seasonal Crop ET under Non-drought Conditions

Research quantified an average seasonal ET of processing tomatoes, determined on eight tomato fields near the WSREC over a 4-year period. However, adjustments may be needed to account for crop season differences and for any unusual seasonal weather effects. For example, the seasonal ET ranged from 20.8 inches for a crop season of 109 days to 29.2 inches for a crop season of 147 days.

Strategies for Coping with Drought

Strategies for coping with drought conditions include the following:

Strategy 1: Reduce the irrigated acreage to match the water supply.

Strategy 2: Fully-irrigate during the first part of the crop season followed by little or no irrigation for the remainder of the season.

Strategy 3: Deficit irrigate the entire crop season by applying seasonal irrigation amounts less than that needed for maximum yield.

Strategy 4: Replace surface water with ground water where possible.

Strategy 1: Reduce the irrigated acreage to match the water supply.

Reduce the irrigated acreage to match the water supply. The reduced acreage is fully-irrigated using normal irrigation practices, resulting in maximum yield per acre. The remaining acreage is not irrigated, resulting in no yield. The fully-irrigated acreage must be irrigated as efficiently as possible by reducing surface runoff and deep percolation below the root zone to stretch the limited water supply. A concern with this strategy is the allocated water supply should last the entire crop season. If additional water supply reductions occur later in the season, the crop on the planted acreage could be under-irrigated.

Strategy 2: Fully-irrigate during the first part of the crop season followed by little or no irrigation for the remainder of the season.

This strategy is a variation of the normal irrigation practice of fully irrigating during the period of canopy development/fruit set, then reducing (cutback approach) or terminating (cutoff approach) irrigation during the later part of the season to improve soluble solids. Implementation of this strategy under drought conditions involves more severe reductions and/or cutoff periods compared to normal irrigation practices and is more appropriate for drip

irrigation than for furrow irrigation. This strategy may increase the irrigated acreage compared to Strategy 1.

Using Drip Irrigation

Experiments conducted in 1992, 1993, 1994, and 1995 and in 2010, 2011, and 2012 evaluated the effect of various levels of late-season irrigation water cutbacks on crop yield and quality of drip-irrigated processing tomatoes. The earlier studies were conducted at the University of California West Side Research and Extension Center (WSREC) and the later studies were done in a commercial field near the WSREC. Soil types for the earlier experiments were clay loam and sandy loam while that of the commercial field experiments was clay loam. Water applications of the WSREC experiments ranged from 100 percent of the tomato ET, calculated using the CIMIS reference crop ET and appropriate crop coefficients, down to 25 percent of the tomato ET, while those of the commercial field ranged from 100 percent ET down to 50 percent ET. Normal cultural practices were used at both locations. Cutback irrigation started 60 days before harvest for both experiments.

Results showed that yield was reduced as the amount of applied water decreased for both experiments (Figure 2). However, for the 50 percent ET and 75 percent ET cutback treatments, yields of both exceeded 90% of the 100 percent ET irrigation water treatment in clay loam. Yields of the 25 percent ET cutback treatment were at least 85% of the maximum yields for the clay loam soil. For the sandy loam soil, yields of the 75 percent ET cutback treatment were similar to those in the clay loam, but yields were much smaller for the 50 percent ET and 25 percent ET cutback treatments in this soil. Soluble solids increased as the amount of applied water decreased.

These results suggest that during periods of limited irrigation water supplies, irrigation amounts under drip irrigation during the later part of the crop season may be decreased to smaller values than normally applied with a minimum crop yield effect on clay loam soils. However, yield reductions may be severe in sandy loam soil. The different yield responses between the soil types reflect differences in soil moisture storage capacity of the two soils. Clay loam soils have a higher soil moisture storage capacity compared to sandy loam soils. This strategy assumes that sufficient irrigation water will be available during the canopy development/fruit set growth stages.

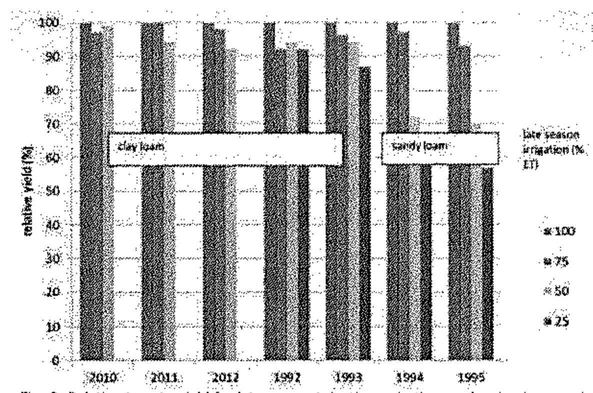

Fig. 2. Relative tomato yield for late season irrigation reductions under clay loam and sandy loam soils.

Using Furrow Irrigation

The cutback approach is difficult to apply under furrow irrigation because of problems of applying small amounts of water throughout the field at a high uniformity of applied water. Thus, a cutoff approach is recommended where irrigations are terminated prior to harvest.

An experiment at the WSREC showed reduced yields of furrow irrigated processing tomatoes on clay loam as the cutoff time increased from 20 days to 80 days before harvest. The yield of the 80-day cutoff treatment was about 81 percent of that of the 20-day cutoff treatment (Figure 3).

Early Season Irrigation

High yields are attainable under either cutback or cutoff strategies if adequate irrigation occurs during the canopy development/fruit set growth stages. Under no-water stress conditions during this growth stage, yield was reduced to about 88% of the maximum yield for a 60-day cutoff period on a clay loam soil, whereas water stress during the canopy development period resulted in a yield of 78% of the maximum yield (Figure 4).

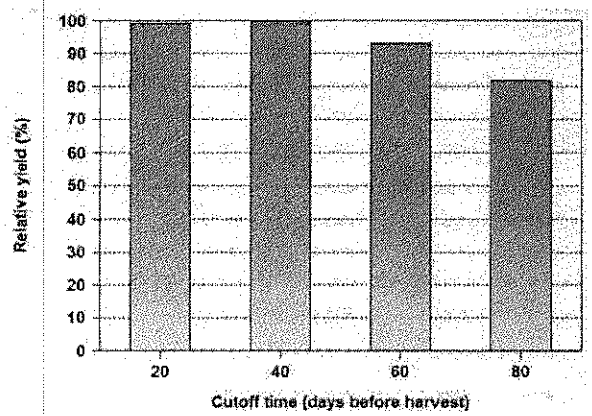

Fig. 3. Effect of cutoff time on yield under furrow irrigation on a clay loam soil. From Don May, 1998.

Soluble solids increased as the amount of irrigation water decreased with the cutoff or cutback. Thus, the solids yields may be only slightly affected by these strategies.

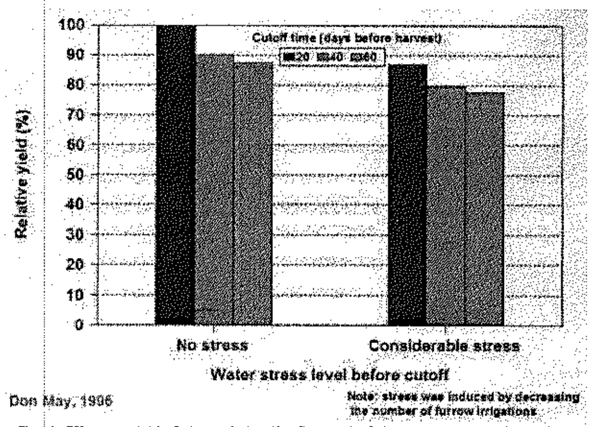

Fig. 4. Effect on yield of stress during the first part of the crop season under various cutoff times (furrow irrigation).

Some guidelines for this strategy are:

- Start the irrigation season with a full supply of soil moisture in the root zone.
- Fully irrigate for at least 60 to 80 days after planting until the canopy is fully established. Failure to fully establish the canopy will reduce yields to levels smaller than would occur for an established canopy. The amount of ET needed to reach full canopy coverage may be 6 to 10 inches of water.
- For the remaining crop season, reduce or cutoff the irrigation water. The effect of these strategies on crop yield may be smaller for clay loam soils compared to sandy loams. At the beginning of the cutback or cutoff period, ensure that the root zone soil moisture is fully replenished.
  - Drip irrigation - cutback or reduce the amount of irrigation water for the rest of the crop season by applying small amounts per irrigation. The amount and timing of the cutback will depend on the amount of available irrigation water.
  - Furrow irrigation – cutoff the irrigation for the remainder of the crop season. The cutoff time will depend on the amount of irrigation water.

Strategy 3: Deficit irrigate the entire crop season by applying seasonal irrigation amounts less than that needed for maximum yield.

Deficit irrigate the irrigated acreage by distributing the limited water supply throughout the crop season. This may be accomplished by applying less water per irrigation, reducing the

number of irrigations, or some combination thereof. This strategy will reduce the ET and thus the yield since tomato yield is directly related to seasonal ET.

Strategy 4: Replace surface water with groundwater where possible.

Using ground water to replace surface water can help mitigate the effect of limited surface water supplies. The amount of acreage that can be irrigated using ground water will depend on the ground water supply. One concern with this strategy is the effect of ground water quality on yield. The ground water may be higher in salt and boron, the accumulation of which can reduce yield. More leaching may be needed to prevent excessive salt and boron accumulation. The effect may not be too noticeable for the first year of irrigating with the ground water, but subsequent years of using ground water may cause excessive soil salinity levels.

Soil salinity may have a smaller effect on crop yield under drip irrigation compared to furrow irrigation due to the salt distribution patterns under each irrigation method. As water flows from the furrow to the middle of the bed, salt is carried with it. Thus, the highest salinity levels are in the middle of the bed and the lowest levels near the furrow. Installing drip lines in the middle of the bed, causes water to flow from the drip line towards the furrow where salts can accumulate. The lowest salinity levels are around the drip line where root density is the highest. However, under subsurface drip irrigation, salt can accumulate above the drip line. Periodic leaching with sprinklers may be needed to control this salt accumulation.

Which Strategy is the Best?

Strategy	
1	Reduce the irrigated acreage to match the water supply
2	Fully irrigate during the first part of the crop season followed by little or no irrigation for the remainder of the season
3	Deficit- irrigate the entire crop season by applying seasonal irrigation amounts less than that needed for maximum yield
4	Replace surface water with ground water where possible

A concern during drought periods is that water allocations promised early in the year may be reduced later in the crop season. This could be a problem for Strategies 1 and 3, which require irrigations throughout the crop season. Under Strategy 2, the effect of additional water allocation reductions late in the crop season may be minimal.

The best strategy is the one that provides the highest economic returns to land and management. The returns are the difference between revenue and cost. Revenue depends on yield and crop price. Costs included variable costs due to irrigation, harvest, and cultural costs (land preparation, fertilization, diseases and insect control), and fixed operating costs. Unfortunately, it is difficult to predict the effect of various water management strategies on yield since as applied water decreases the crop ET also decreases. The result is that yield will also decrease. The amount of reduction may be site-specific and not possible to estimate.

Production costs will depend on the strategy to some degree. Variable production costs per acre may be similar for Strategies 1, 2, and 4. But the total production costs per acre may be smaller for Strategy 3 because of reduced irrigations and smaller yields per acre.

Strategies 1 and 4 have the smallest risk because they simply involve reducing the irrigated acreage and then irrigating the reduced acreage using normal irrigation practices to obtain maximum yield per acre on the irrigated acres. For Strategy 4, the amount of reduction will depend on the ground water supply. Strategy 3, commonly recommended by researchers of deficit irrigation, probably has the greatest risk because the effect of deficit irrigation throughout the season on yield is unknown for a given field other than it will be reduced.

The risk of Strategy 2 is the cumulative effect of the cutback period and the reduced water applications on yield. This strategy involves normal irrigation practices during the canopy development/ fruit stages (assuming sufficient irrigation water) and then reduced irrigations thereafter. If the reduced irrigations start 60 days before harvest, the research shows relatively small yield effects even for water applications as limited as 25% of the normal application. If the cutbacks start earlier than 60 days before harvest, the the cumulative effect of a longer cutback period and reduced water applications on yield is unknown but expected to be less.

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UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION

2007

SAMPLE COSTS TO PRODUCE FRESH MARKET

TOMATOES

SAN JOAQUIN VALLEY

Furrow Irrigated

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UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION

SAMPLE COSTS TO PRODUCE FRESH MARKET TOMATOES
San Joaquin Valley - 2007

CONTENTS

Sample costs to produce fresh market tomatoes in the San Joaquin Valley are presented in this study. This study is intended as a guide only, and can be used to make production decisions, determine potential returns, prepare budgets and evaluate production loans. Practices described are based on those production practices considered typical for the crop and area, but will not apply to every farm. Sample costs for labor, materials, equipment and custom services are based on current figures. A blank column, "*Your Costs*", in Tables 1 and 2 is provided to enter your farming costs.

The hypothetical farm operation, production practices, overhead, and calculations are described under the assumptions. For additional information or an explanation of the calculations used in the study call the Department of Agricultural and Resource Economics, University of California, Davis, (530) 752-3589 or your local UC Cooperative Extension office.

Sample Cost of Production Studies are available for many commodities. All current and some archived studies can be downloaded from the Agricultural and Resource Economics website at UC Davis http://coststudies.ucdavis.edu. These studies as well as other archived studies not on the website can be requested through the department by calling (530) 752-1517.

ASSUMPTIONS

The following assumptions refer to Tables 1 to 7 and pertain to sample costs to produce fresh market tomatoes in the San Joaquin Valley. The cultural practices described represent production operations and materials considered typical for a well managed farm in the region. Costs, materials, and practices in this study will not apply to all farms. Timing and types of cultural practices will vary among growers within the region and from season to season due to variables such as weather, soil, insect and disease pressure. This cost study is intended as a guide only. For more information on California fresh market tomato production visit the UC Vegetable Research and Information Center website at www.vric.ucdavis.edu. **The use of trade names and cultural practices in this report does not constitute an endorsement or recommendation by the University of California nor is any criticism implied by omission of other similar products or cultural practices.**

Farm. The cost study is based on a hypothetical non-contiguous 1,200 acre farm of which 150 rented acres are planted to fresh market tomatoes. Other crops grown on the farm are almonds and crops in rotation with tomatoes may include small grains, cotton, corn, cantaloupes, peppers, green and dry beans. The rented land includes developed wells and irrigation system. All costs for the land and the irrigation system including property taxes are incurred by the landowner.

Cultural Practices and Material Inputs

Land Preparation. Primary tillage is done in the fall (November in this study) preceding planting. Tillage operations consist of disking twice, chiseling twice, triplaning twice, spreading a soil amendment, disking, listing beds, shaping beds and applying herbicide. When an operation is done twice, it is usually in two different directions. The crop year in this study begins with land preparation in November and continues through harvest.

Planting. No specific fresh market variety is planted in this study, except that the data is based on early to midseason plantings and harvest. Beds on five-foot centers are made in the fall with a three-row lister and shaped with a bed-shaper. In the spring, the beds are cultivated with a rolling cultivator to mulch the surface. The seedlings (transplants) are grown by a commercial greenhouse from seed supplied by the grower. The cost for both the seed and seedlings are included in the planting costs. Seedlings (transplants) are planted from mid-February through July using a three-row transplanter. A mid-April planting date is used in this report. The plants are spaced 16 inches apart in a single row on 60 inch beds, for a total of 6,550 plants per acre. The planting crew uses one tractor driver, six persons on the transplanter, one water truck driver, and one additional person for miscellaneous work.

Nutrition. In the fall during land preparation, one to two tons of gypsum or lime is applied to the field. Two tons of gypsum are applied in this study. Nitrogen (N), phosphorus (as P_2O_5) and potassium (as K_2O) plus zinc are supplied from a complete liquid fertilizer blend, 8-8-8, preplant incorporated at 1,000 pounds per acre into the bed below the planting line. Fertilizer as 10-34-0 at 3.5 gallons (41.3 pounds) per acre, zinc at 0.50 gallon and humic acid at 1 gallon per acre are added to the transplant water for a total of 5 gallons of material. Seventy pounds of N as UN-32 are sidedressed in May. Ten pounds of N per acre from CAN17 are applied in the irrigation water (water-run N) in June, giving a total of 164 pounds of N for the season from all nitrogen fertilizers applied.

Fertilizer Analysis. Soil samples are taken in the fall prior to land preparation and tissue samples are taken once in early June by the PCA or as a custom service by a commercial lab. For each collection, one sample per 20 acres is taken. Costs shown are for the lab analysis ($2) and for collection by the PCA ($2).

Irrigation. Furrow irrigation using siphon tubes are used for this study. The irrigation water is supplied by the local irrigation district at $40 per acre foot ($3.33 per acre inch) plus $20 per acre stand-by charge and other administrative costs (paid by landlord). The first irrigation occurs in April shortly after planting, followed by subsequent irrigations at 8 to 12 day intervals depending on the weather in May, June and early July. A total of 36 acre-inches are applied to the crop.

Pest Management. The pesticides and rates mentioned in this cost study are listed in *Integrated Pest Management for Tomatoes* and *UC Pest Management Guidelines, Tomato*. For more information on pest identification, monitoring, and management visit the UC IPM website at www.ipm.ucdavis.edu. For information and pesticide use permits, contact the local county Agricultural Commissioner's office. Adjuvants or surfactants may be recommended for use with some pesticides, but are not included in this study. Pesticide costs vary by location and grower volume. Pesticide costs in this study are taken from a single dealer and shown as full retail.

All tomato fields will experience some pest incidence, but the specific pests and management will vary between fields due to planting date, location, microclimate, and pest pressure. Integrated pest management is used to control weeds, insects, diseases, and related pests. Controls in this study are based on early to midseason plantings.

Pest Control Adviser (PCA). The PCA or crop consultant monitors the field for agronomic problems including pests and nutrition and writes pesticide recommendations. Growers may hire private PCAs or receive the service as part of a service agreement with an agricultural chemical and fertilizer company. An independent PCA is assumed for this study, with a seasonal rate of $20 per acre plus additional charges for collecting soil and tissue samples.

Weeds. The most troublesome weeds in tomatoes are field bindweed, nightshade, nutsedge, purslane, and occasionally dodder. Treflan is applied to the beds in the fall during listing and Roundup is applied to the fallow beds in March. Prior to transplanting in the spring, Treflan and Dual are applied and incorporated into the beds. Dual is also applied at layby in June. Weed control also includes hand hoeing prior to layby (June) and three mechanical cultivations – one in April prior to planting to breakup the surface and two after planting (May, June).

Insects. General foliage and fruit feeders are tomato fruitworms, various armyworms, leafminers, russet mites, stink bugs, thrips, and potato aphids. Beet leafhoppers and pinworms are an occasional problem. In this study beet leafhoppers (*Circulifer tenellus*) and thrips (various species), consperse stink bug (*Euschistis conspersus*), russet mite (*Aculops lycopersici*), and armyworm (*Spodoptera spp.*) are the target pests. The insects and mites are controlled with three ground applications of insecticides. The first application is at or within a few weeks of planting (April); the second is 4-5 weeks after planting (May); and the third is at layby in June. The first application is a transplant water drench or sidedress of Admire Pro for thrips and leafhoppers. The russet mites, stinkbugs, and worms are managed with two tank mix applications. The first application contains Kelthane for russet mite and Asana for stink bug. The second application contains Asana, Agri-Mek, and Avaunt for stinkbug, russet mite and armyworms.

Disease. Although there are many diseases affecting tomatoes, incidence is usually patchy and left untreated. However, early to midseason plantings may require copper protectant applications for bacterial speck or fungicide protection from late blight, while mid to late season plantings may require fungicide applications to prevent or minimize damage from powdery mildew, late blight, and black mold. Bacterial speck (*Pseudomonas syringae* pv. *tomato*) in this study is prevented with two ground applications of Kocide (copper) and Dithane fungicide in late April and early May. Tomato spotted wilt, a viral disease transmitted by thrips, has been increasing in tomatoes in the San Joaquin Valley and for that reason thrips control is included under insect management costs.

Harvest. The tomato crop is hand harvested 80 to 110 days after transplanting (mid to late July in this study) by contract labor. Tomatoes are picked and hauled from the field to the packing shed. A tractor pulls a flatbed trailer with a gondola through the field, one trailer per 35 to 40 persons picking crew, one-half the crew working on each side of the trailer. Each picker has two 5-gallon buckets holding about 35 pounds of fruit. The picker takes about 2 to 2.5 minutes to fill two buckets, go to the trailer, hand buckets to dumper, record dump with checker and return to picking. One dumper is on each side of the trailer to dump the buckets and one checker stands at the end of the trailer to record picker's dumps. Custom harvesting of the tomatoes costs $62 per gross ton plus $12 per gross ton to haul the tomatoes to the packing shed for a total of $74 per gross ton.

Yields. Gross crop yields range from 12 to 25 tons per acre in the San Joaquin Valley. The average packout rate ranges from 60-75 percent, netting 8-18 tons per acre of marketable fruit. In general early to mid-season tomatoes (transplanted February – May) have higher yields than late season tomatoes (June – July transplant dates). This study assumes a gross yield of 18 tons and a packout rate of 72% netting 13 tons or 1,040 packed 25 pound boxes. The $74 picking and hauling cost per gross ton equates to $1.28 per packed box.

Packing. Packing fees vary between sheds and include the costs of packing labor, packaging materials such as cartons and pallets, selling fees, and miscellaneous costs. This study uses a packing fee of $2.50 per 25 pound box. The total harvest and packing cost is $3.78 per packed box.

Returns. Growers may produce some tomatoes under contract, but most are sold on the open market and prices will vary. Differences in fresh market tomato prices and yields can be substantial over the season. Average prices for San Joaquin Valley growers for 2002 to 2006 (County Ag Commissioner Reports) are $6.38 per box ranging from $4.85 to $7.69. Due to the market fluctuation of prices received by growers, an assumed return price rounded to $6.50 per box is used in this study based on the 2005 to 2006 average. Table 4, Ranging Analysis, shows the net returns above operating costs, cash costs and total costs for various price and yield levels.

Assessments. Tomato growers are assessed a fee for the Curly Top Virus Control Program (CTVCP) administered by the California Department of Food and Agriculture (CDFA). Growers in District II pay $0.127 per net ton. District II includes San Joaquin Valley counties from Merced to Kern.

Field Cleanup. After harvest, the crop residue is mulched with a flail-type mower, then disked in two passes with a stubble disk.

Truck/Pickup. General pickup use is listed as a separate line item. A water truck is used during the season to water the roads usually daily and twice a day during the harvest season. The mileage and times are estimated and not taken from any specific data.

Labor, Equipment, and Interest Costs

Labor. Labor rates of $13.50 per hour for machine operators and $10.80 for general labor includes payroll overhead of 35%. The basic hourly wages are $10.00 for machine operators and $8.00 for general labor. The overhead includes the employers' share of federal and California state payroll taxes, workers' compensation insurance for truck crops (code 0172), and a percentage for other possible benefits. Workers' compensation

costs will vary among growers, but for this study the cost is based upon the average industry final rate as of January 1, 2007 (personal email from California Department of Insurance, May 18, 2007, unreferenced). Labor for operations involving machinery are 20% higher than the operation time given in Table 1 to account for the extra labor involved in equipment set up, moving, maintenance, work breaks, and field repair.

Equipment Operating Costs. Repair costs are based on purchase price, annual hours of use, total hours of life, and repair coefficients formulated by American Society of Agricultural Engineers (ASAE). Fuel and lubrication costs are also determined by ASAE equations based on maximum power takeoff (PTO) horsepower, and fuel type. Prices for on-farm delivery of diesel and gasoline are $2.30 and $2.80 per gallon, respectively. Fuel costs are derived from American Automobile Association (AAA) and Energy Information Administration 2006 monthly data. The cost includes a 2% local sales tax on diesel fuel and 8% sales tax on gasoline. Gasoline also includes federal and state excise tax, which are refundable for on-farm use when filing your income tax. The fuel, lube, and repair cost per acre for each operation in Table 1 are determined by multiplying the total hourly operating cost in Table 6 for each piece of equipment used for the selected operation by the hours per acre. Tractor time is 10% higher than implement time for a given operation to account for setup, travel and down time.

Interest on Operating Capital. Interest on operating capital is based on cash operating costs and is calculated monthly until harvest at a nominal rate of 10.00% per year. A nominal interest rate is the typical market cost of borrowed funds. The interest cost of post harvest operations is discounted back to the last harvest month using a negative interest charge. The rate will vary depending upon various factors, but the rate in this study is considered a typical lending rate by a farm lending agency as of January 2007.

Risk. Perishability of fresh vegetables diminishes the opportunity to wait for a better market and price. Because of the risk involved, access to a market is crucial. A market channel should be determined before any tomato production begins. Fresh market vegetables are a high risk enterprise because the market for fresh vegetables is volatile for both price and quantity. Risk is caused by uncontrollable factors such as a decrease in the demand, an oversupply, weather causing planting and harvesting delays, and diseases and insects which may lower quality.

Cash Overhead

Cash overhead consists of various cash expenses paid out during the year that are assigned to the whole farm and not to a particular operation. These costs include property taxes, interest on operating capital, office expense, liability and property insurance, and investment repairs.

Property Taxes. Counties charge a base property tax rate of 1% on the assessed value of the property. In some counties special assessment districts exist and charge additional taxes on property including equipment, buildings, and improvements. For this study, county taxes are calculated as 1% of the average value of the property. Average value equals new cost plus salvage value divided by two on a per acre basis.

Insurance. Insurance for farm investments vary depending on the assets included and the amount of coverage. Property insurance provides coverage for property loss and is charged at 0.714% of the average value of the assets over their useful life. Liability insurance covers accidents on the farm and costs $1,296 for the entire farm.

Office Expense. Office and business expenses are estimated at $75 per acre. These expenses include office supplies, telephones, bookkeeping, accounting, and legal fees for whole farm. The cost is a general estimate and not based on any actual data.

Land Rent. Land rents for the eight counties in the San Joaquin Valley depend on the irrigation district (2007 Trends and Leases) and ranged from $100 to $350 per acre. Land rents according to growers in the area ranged from $225 to $250 per acre. For this study, $250 is the rental value and the landowner pays the basic monthly water service charge (standby and administrative charges) and the grower pays the cost for the water used.

Sanitation Rental. The cost includes double unit toilets with washbasins, delivered and serviced weekly. The double toilets with hand washing facilities are rented for five months of weekly service beginning in mid March. The number of toilets required depends upon crew size.

Environmental Fees. Growers are assessed various fees by government agencies to protect the environment. Examples of some fees are water quality, air quality, pesticide permits, etc. Some are charged per farm or grower and some by the acre. For example an air quality permit costs $75 to $150 per grower, whereas growers must belong to a water coalition for surface water monitoring that cost $5 per acre. For this study a fee is estimated based on some available data as reported by the growers plus some charges not currently known.

Non-Cash Overhead

Non-cash overhead is calculated as the capital recovery cost for equipment and other farm investments.

Capital Recovery Costs. Capital recovery cost is the annual depreciation and interest costs for a capital investment. It is the amount of money required each year to recover the difference between the purchase price and salvage value (unrecovered capital). It is equivalent to the annual payment on a loan for the investment with the down payment equal to the discounted salvage value. This is a more complex method of calculating ownership costs than straight-line depreciation and opportunity costs, but more accurately represents the annual costs of ownership because it takes the time value of money into account (Boehlje and Eidman). The formula for the calculation of the annual capital recovery costs is ((Purchase Price – Salvage Value) x Capital Recovery Factor) + (Salvage Value x Interest Rate).

Salvage Value. Salvage value is an estimate of the remaining value of an investment at the end of its useful life. For farm machinery (tractors and implements) the remaining value is a percentage of the new cost of the investment (Boehlje and Eidman). The percent remaining value is calculated from equations developed by the American Society of Agricultural Engineers (ASAE) based on equipment type and years of life. The life in years is estimated by dividing the wearout life, as given by ASAE by the annual hours of use in this operation. For other investments including irrigation systems, buildings, and miscellaneous equipment, the value at the end of its useful life is zero. The salvage value for land is the purchase price because land does not depreciate. The purchase price and salvage value for equipment and investments are shown in Table 5.

Capital Recovery Factor. Capital recovery factor is the amortization factor or annual payment whose present value at compound interest is 1. The amortization factor is a table value that corresponds to the interest rate used and the life of the machine.

Interest Rate. An interest rate of 7.25% is used to calculate capital recovery. The rate will vary depending upon loan amount and other lending agency conditions, but is the basic suggested rate by a farm lending agency as of January 2007.

Building. The metal building(s) are on a cement slab and total approximately 2,400 square feet. The buildings are used for shops and equipment storage.

Fuel Tanks. Two 350 gallon fuel tanks are on metal stands in cement containment meeting federal and state regulations.

Shop/Field Tools. Includes shop equipment and tools and small tools and/or small hand equipment used in the field.

Siphon Tubes. The grower owns 300 two-inch siphon tubes used mainly on the tomatoes.

Equipment. Farm equipment is purchased new or used, but the study shows the current purchase price for new equipment. The new purchase price is adjusted to 60% to indicate a mix of new and used equipment. Annual ownership costs for equipment and other investments are shown in Table 6. Equipment costs are composed of three parts: non-cash overhead, cash overhead, and operating costs. Both of the overhead factors have been discussed in previous sections. The operating costs consist of repairs, fuel, and lubrication and are discussed under operating costs.

Table Values. Due to rounding, the totals may be slightly different from the sum of the components.

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UC COOPERATIVE EXTENSION

Table 1. COSTS PER ACRE TO PRODUCE FRESH MARKET TOMATOES

SAN JOAQUIN VALLEY – 2007

	Operation	Cash and Labor Costs per Acre					
	Time	Labor	Fuel, Lube	Material	Custom/	Total	Your
Operation	(Hrs/A)	Cost	& Repairs	Cost	Rent	Cost	Cost
Cultural:							
Nutrition: Soil Sampling (PCA, analysis)	0.00	0	0	0	4	4	
Land Prep: Stubble Disk 2X	0.30	5	12	0	0	17	
Land Prep: Chisel 2X	0.60	10	25	0	0	34	
Land Prep: Triplane 2X	0.24	4	10	0	0	14	
Nutrition: Soil Amendments (gypsum)	0.22	4	6	84	0	94	
Land Prep: Disk	0.10	2	4	0	0	6	
Land Prep/Weed: List Beds/Spray Treflan	0.20	3	8	3	0	14	
Land Prep: Shape Beds/Incorporate Treflan	0.25	4	10	0	0	14	
Weed: Spray Beds (Roundup)	0.10	2	3	24	0	29	
Weed: Cultivate (break up surface)	0.14	2	2	0	0	5	
Nutrition: Shank Fertilizer (8-8-8+Zn)	0.22	4	7	70	0	80	
Weed: Spray & Incorporate herbicide (Treflan, Dual)	0.25	4	8	23	0	36	
Plant: Transplant. Fertilize (10-34-0+Zn+Humic). Insect: Thrips, Leafhoppers (Admire)	0.33	38	9	464	0	511	
Irrigate: Make Ditches	0.06	1	2	0	0	3	
Irrigate: (water & labor)	3.50	38	0	120	0	158	
Disease: Speck (Kocide, Dithane) 2X	0.20	3	6	26	0	35	
Irrigate: Close Ditch & Drag	0.06	1	2	0	0	3	
Weed: Cultivate	0.55	9	10	0	0	19	
Weed: Hand Hoe	0.00	0	0	0	70	70	
Insect: Stinkbug, Mites (Asana, Kelthane)	0.10	2	3	16	0	20	
Nutrition: Fertilize Sidedress (UN32)	0.22	4	7	32	0	43	
Nutrition: Tissue (leaf) Sampling	0.00	0	0	0	4	4	
Insect: Stinkbug, Mites, Worms (Asana AgriMek Avaunt)	0.10	2	3	127	0	132	
Weed: Layby (Dual)	0.14	2	3	20	0	25	
Nutrition: Fertilize Waterrun (CAN 17)	0.00	0	0	8	0	8	
Pest Control Adviser	0.00	0	0	0	20	20	
Water Truck	0.08	1	1	0	0	2	
Pickup	0.83	14	8	0	0	22	
Clean Up: Mow/Shred plants (post harvest)	0.14	2	5	0	0	7	
Clean Up: Disk crop residue (post harvest)	0.29	5	11	0	0	16	
TOTAL CULTURAL COSTS	9.25	163	164	1,017	98	1,443	
Harvest:							
Field Pick	0.00	0	0	0	1,116	1,116	
Haul To Shed	0.00	0	0	0	216	216	
Box, Pack & Sell	0.00	0	0	0	2,600	2,600	
Assessment:	0.00	0	0	2	0	2	
TOTAL HARVEST COSTS	0.00	0	0	2	3,932	3,934	
Interest on operating capital @ 10.00%						82	
TOTAL OPERATING COSTS/ACRE		163	164	1,019	4,030	5,458	

UC COOPERATIVE EXTENSION
Table 1. Continued
SAN JOAQUIN VALLEY 2007

Operation	Operation Time (Hrs/A)	Labor Cost	Fuel, Lube & Repairs	Material Cost	Custom/ Rent	Total Cost	Your Cost
CASH OVERHEAD:							
Liability Insurance						1	
Office Expense						75	
Rent - Tomato Land						250	
Sanitation (Portable Washing & Toilets)						8	
Environmental Fees						10	
Property Taxes						4	
Property Insurance						3	
Investment Repairs						2	
TOTAL CASH OVERHEAD COSTS						352	
TOTAL CASH COSTS/ACRE						5,810	
NON-CASH OVERHEAD (Capital Recovery):		Per producing Acre		Annual Costs Capital Recovery			
Buildings, 2400 sqft		63		5		5	
Tools: Shop/Field		13		1		1	
Fuel Tanks		3		0		0	
Siphon Tubes		28		7		7	
Equipment		500		65		65	
TOTAL NON-CASH OVERHEAD COSTS		605		79		79	
TOTAL COSTS/ACRE						5,889	
TOTAL COST/BOX						5.66	

UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
Table 2. COSTS and RETURNS PER ACRE to PRODUCE FRESH MARKET TOMATOES
SAN JOAQUIN VALLEY - 2007

	Quantity Acre	Unit	Price or Cost/Unit	Value or Cost/Acre	Your Cost
GROSS RETURNS					
Tomatoes Fresh Market	1,040.00	box-25 lb	6.50	6,760	
TOTAL GROSS RETURNS				6,760	
OPERATING COSTS					
Custom/Contract:					
Soil Analysis	0.05	each	40.00	2	
Tissue Analysis	0.05	each	40.00	2	
Pick Tomatoes	18.00	ton	62.00	1,116	
Haul Tomatoes	18.00	ton	12.00	216	
Pack Tomatoes	1,040.00	box	2.50	2,600	
Hand Weed (hoe)	1.00	acre	70.00	70	
Pest Control Adviser (collect soil & tissue samples)	0.10	each	40.00	4	
Pest Control Advisor (PCA)	1.00	acre	20.00	20	
Fertilizer/Soil Amendments:					
Gypsum	2.00	ton	42.00	84	
8-8-8	1,000.00	lb	0.06	60	
Zinc Chelate 6% (9.21 lbs/gal)	10.00	lb	1.00	10	
10-34-00	41.30	lb	0.16	7	
Zinc (% unknown) Western Farm	0.50	gal	14.00	7	
Humic Acid	1.00	gal	9.00	9	
UN32	70.00	lb N	0.46	32	
CAN 17 (17-0-0)	10.00	lb N	0.78	8	
Herbicide:					
Triflurex HFP	2.00	pint	2.97	6	
Roundup Ultra Max	3.00	pint	8.00	24	
Dual II Magnum	2.00	pint	20.15	40	
Seed:					
Tomato Seed	6.55	thou	22.00	144	
Tomato Transplants	6.55	thou	28.00	183	
Irrigation:					
Water	36.00	acin	3.33	120	
Fungicide:					
Kocide DF	4.00	lb	2.55	10	
Dithane DF Rainshield	4.00	lb	3.89	16	
Insecticide:					
Admire Pro	10.00	floz	11.40	114	
Asana XL	16.00	floz	1.08	17	
Kelthane MF	1.00	pint	7.29	7	
Agri-Mek 0.15EC	12.00	floz	7.82	94	
Avaunt	3.50	oz	7.05	25	
Assessment:					
CDFA-Curly Top Virus Program	13.00	ton	0.13	2	

UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
Table 2. CONTINUED
SAN JOAQUIN VALLEY - 2007

	Quantity Acre	Unit	Price or Cost/Unit	Value or Cost/Acre	Your Cost
Labor (machine)	6.90	hrs	13.50	93	
Labor (non-machine)	6.50	hrs	10.80	70	
Fuel - Gas	2.08	gal	2.80	6	
Fuel - Diesel	45.90	gal	2.30	106	
Lube				17	
Machinery repair				36	
Interest on operating capital @ 10.00%				82	
TOTAL OPERATING COSTS/ACRE				5,458	
NET RETURNS ABOVE OPERATING COSTS				1,302	
CASH OVERHEAD COSTS:					
Liability Insurance				1	
Office Expense				75	
Rent - Tomato Land				250	
Sanitation (Portable Washing & Toilets)				8	
Environmental Fees				10	
Property Taxes				4	
Property Insurance				3	
Investment Repairs				2	
TOTAL CASH OVERHEAD COSTS/ACRE				352	
TOTAL CASH COSTS/ACRE				5,810	
NON-CASH OVERHEAD COSTS (Capital Recovery)					
Buildings, 2400 sqft				5	
Tools: Shop/Field				1	
Fuel Tanks				0	
Siphon Tubes				7	
Equipment				65	
TOTAL NON-CASH OVERHEAD COSTS/ACRE				79	
TOTAL COSTS/ACRE				5,889	
NET RETURNS/ ACRE				871	

UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
Table 3. MONTHLY CASH COSTS PER ACRE TO PRODUCE FRESH MARKET TOMATOES
SAN JOAQUIN VALLEY –2007

Beginning NOV 06 Ending OCT 07	NOV 06	DEC 06	JAN 07	FEB 07	MAR 07	APR 07	MAY 07	JUN 07	JUL 07	AUG 07	SEP 07	OCT 07	TOTAL
Cultural:													
Nutrition: Soil Sampling	4												4
Land Prep: Stubble Disk 2X	17												17
Land Prep: Chisel 2X	34												34
Land Prep: Triplane 2X	14												14
Nutrition: Soil Amendments (gypsum)	94												94
Land Prep: Disk	6												6
Land Prep/Weed: List Beds/Spray Treflan	14												14
Land Prep: Shape Beds/Incorporate Treflan		14											14
Weed: Spray Beds (Roundup)					29								29
Weed: Cultivate (break up surface)						5							5
Nutrition: Shank Fertilizer (8-8-8+Zn)						80							80
Weed: Spray & Incorporate herbicide (Treflan, Dual)						36							36
Plant/Nutrition: Transplant/Fertilize (10-34-0+Zn+Humic), Insect: Thrips, Leafhoppers (Admire)						511							511
Irrigate: Make Ditches						1		2					3
Irrigate: (water & labor)						23	45	68	23				158
Disease: Speck (Kocide, Dithane) 2X						17	17						35
Irrigate: Close Ditch & Drag							1	1	1				3
Weed: Cultivate							9	9					19
Weed: Hand Hoe							70						70
Insect: Stinkbug, Mites (Asana, Kelthane)							20						20
Nutrition: Fertilize Sidedress (UN32)							43						43
Nutrition: Tissue (leaf) Sampling								4					4
Insect: Stinkbug, Mites, Worms (Asana AgriMek Avaunt)								132					132
Weed: Layby (Dual)								25					25
Nutrition: Fertilize Waterrun (CAN 17)								8					8
Pest Control Adviser (PCA)	2	2	2	2	2	2	2	2	2	2			20
Water Truck	0	0	0	0	0	0	0	0	0	0			2
Pickup	2	2	2	2	2	2	2	2	2	2			22
Clean Up: Chop/Mulch plants (post harvest)										7			7
Clean Up: Disk crop residue (post harvest)										16			16
TOTAL CULTURAL COSTS	188	19	4	4	33	677	210	253	28	27	0	0	1,443

UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
Table 3, continued
SAN JOAQUIN VALLEY 2007

Beginning NOV 06 Ending OCT 07	NOV 06	DEC 06	JAN 07	FEB 07	MAR 07	APR 07	MAY 07	JUN 07	JUL 07	AUG 07	SEP 07	OCT 07	TOTAL
Harvest:													
Field Pick									1,116				1,116
Haul To Shed									216				216
Box, Pack & Sell									2,600				2,600
Assessment:										2			2
TOTAL HARVEST COSTS									3,932	2			3,934
Interest on operating capital @ 10.00%	2	2	2	2	2	8	9	12	45	0			82
TOTAL OPERATING COSTS/ACRE	190	20	6	6	35	684	220	264	4,004	29	0	0	5,458
OVERHEAD:													
Liability Insurance				1									1
Office Expense	8	8	8	8	8	8	8	8	8	8			75
Rent - Tomato Land												250	250
Sanitation (Portable Washing & Toilets)					1	2	2	2	2	1			8
Environmental Fees								10					10
Property Taxes			2						2				4
Property Insurance			1						1				3
Investment Repairs	0	0	0	0	0	0	0	0	0	0	0	0	2
TOTAL CASH OVERHEAD COSTS	8	8	11	9	8	9	9	19	12	8	0	250	352
TOTAL CASH COSTS/ACRE	197	28	17	15	43	693	229	283	4,017	37	0	250	5,810

UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
Table 4. RANGING ANALYSIS
SAN JOAQUIN VALLEY - 2007

COSTS PER ACRE AT VARYING YIELDS TO PRODUCE FRESH MARKET TOMATOES

	*YIELD (BOX/ACRE)						
	920	960	1,000	1,040	1,080	1,120	1,160
OPERATING COSTS/ACRE:							
Cultural Cost	1,443	1,443	1,443	1,443	1,443	1,443	1,443
Harvest (pick)	987	1,030	1,073	1,116	1,159	1,202	1,245
Haul	191	199	208	216	224	233	241
Pack	2,300	2,400	2,500	2,600	2,700	2,800	2,900
Assessment	1	2	2	2	2	2	2
Interest on operating capital @ 10.00%	78	79	81	82	83	84	86
TOTAL OPERATING COSTS/ACRE	5,000	5,153	5,307	5,459	5,611	5,764	5,917
TOTAL OPERATING COSTS/BOX	5.43	5.37	5.31	5.25	5.20	5.15	5.10
CASH OVERHEAD COSTS/ACRE	352	352	352	352	352	352	352
TOTAL CASH COSTS/ACRE	5,352	5,505	5,659	5,811	5,963	6,116	6,269
TOTAL CASH COSTS/BOX	5.82	5.73	5.66	5.59	5.52	5.46	5.40
NON-CASH OVERHEAD COSTS/ACRE	79	79	79	79	79	79	79
TOTAL COSTS/ACRE	5,431	5,584	5,738	5,890	6,042	6,195	6,348
TOTAL COSTS/BOX	5.90	5.82	5.74	5.66	5.59	5.53	5.47

*box = 25 lbs

NET RETURNS PER ACRE ABOVE OPERATING COSTS

Tomatoes	YIELD (BOX/ACRE)						
$/box	920	960	1,000	1,040	1,080	1,120	1,160
4.50	-860	-833	-807	-779	-751	-724	-697
5.50	60	127	193	261	329	396	463
6.00	520	607	693	781	869	956	1,043
6.50	980	1,087	1,193	1,301	1,409	1,516	1,623
7.00	1,440	1,567	1,693	1,821	1,949	2,076	2,203
7.50	1,900	2,047	2,193	2,341	2,489	2,636	2,783
8.00	2,360	2,527	2,693	2,861	3,029	3,196	3,363

NET RETURNS PER ACRE ABOVE CASH COSTS

Tomatoes	YIELD (BOX/ACRE)						
$/box	920	960	1,000	1,040	1,080	1,120	1,160
4.50	-1,212	-1,185	-1,159	-1,131	-1,103	-1,076	-1,049
5.50	-292	-225	-159	-91	-23	44	111
6.00	168	255	341	429	517	604	691
6.50	628	735	841	949	1,057	1,164	1,271
7.00	1,088	1,215	1,341	1,469	1,597	1,724	1,851
7.50	1,548	1,695	1,841	1,989	2,137	2,284	2,431
8.00	2,008	2,175	2,341	2,509	2,677	2,844	3,011

UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
Table 4. CONTINUED
SAN JOAQUIN VALLEY – 2007

NET RETURNS PER ACRE ABOVE TOTAL COSTS

Tomatoes	YIELD (BOX/ACRE)						
$/box	920	960	1,000	1,040	1,080	1,120	1,160
4.50	-1,291	-1,264	-1,238	-1,210	-1,182	-1,155	-1,128
5.50	-371	-304	-238	-170	-102	-35	32
6.00	89	176	262	350	438	525	612
6.50	549	656	762	870	978	1,085	1,192
7.00	1,009	1,136	1,262	1,390	1,518	1,645	1,772
7.50	1,469	1,616	1,762	1,910	2,058	2,205	2,352
8.00	1,929	2,096	2,262	2,430	2,598	2,765	2,932

UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
Table 5. WHOLE FARM ANNUAL EQUIPMENT, INVESTMENT, AND BUSINESS OVERHEAD COSTS
SAN JOAQUIN VALLEY - 2007

						Cash Overhead		
			Yrs	Salvage	Capital	Insur-		
Yr	Description	Price	Life	Value	Recovery	ance	Taxes	Total
07	130 HP 2WD Tractor	93,043	10	27,483	11,435	430	603	12,468
07	200 HP MFWD Tractor	154,000	10	45,489	18,927	712	997	20,636
07	92 HP 2WD Tractor	59,563	10	17,594	7,320	275	386	7,981
07	Bed Shaper - 3 Row	13,292	12	1,841	1,594	54	76	1,724
07	Cultivator-Rolling 3 Row	8,535	12	1,182	1,024	35	49	1,107
07	Disk - Offset 26'	25,071	12	3,472	3,007	102	143	3,252
07	Disk - Stubble 16'	13,176	12	1,825	1,581	54	75	1,709
07	Ditcher - V	8,631	12	1,195	1,035	35	49	1,120
07	Fertilizer Injector	5,091	10	900	669	21	30	720
07	Flail Shredder 15'	13,675	10	2,418	1,797	57	80	1,935
07	Incorporator - 15'	18,644	9	3,725	2,584	80	112	2,776
07	Lister - 3 Row 15'	5,500	12	762	660	22	31	713
07	Pickup 1/2 ton	28,000	5	12,549	4,703	145	203	5,051
07	Saddle Tank 300 gal #1	2,374	5	773	449	11	16	476
07	Saddle Tank 300 gal #2	2,374	5	773	449	11	16	476
07	Scraper - Drag 10'	2,581	18	172	256	10	14	280
07	Spray Boom 20'	1,424	10	252	187	6	8	201
07	Spray Boom 25'	1,781	10	315	234	7	10	252
07	Subsoiler - 8'	12,500	10	2,211	1,642	53	74	1,768
07	Transplanter 3 Row	16,200	10	2,865	2,128	68	95	2,292
07	Triplane - 16'	22,253	12	3,082	2,669	90	127	2,886
07	Truck Water (2 ton)	52,000	10	15,360	6,391	240	337	6,968
TOTAL		559,708		146,238	70,742	2,520	3,530	76,792
	60% of New Cost *	335,825		87,743	42,445	1,512	2,118	46,075

*Used to reflect a mix of new and used equipment

ANNUAL INVESTMENT COSTS

					Cash Overhead			
		Yrs	Salvage	Capital	Insur-			
Description	Price	Life	Value	Recovery	ance	Taxes	Repairs	Total
Buildings 2400 sqft	75,000	30		6,196	268	375	1,500	8,339
Fuel Tanks 2-300 gal	3,200	20	320	300	13	18	64	395
Shop/Field Tools	15,000	20	1307	1,413	58	82	350	1,902
Siphon Tubes (300)	4,200	5		1,031	15	21	84	1,151
TOTAL INVESTMENT	97,400		1,627	8,941	354	495	1,998	11,787

ANNUAL BUSINESS OVERHEAD

	Units/		Price/	Total
Description	Farm	Unit	Unit	Cost
Environmental Fees	1,200	acre	10.00	12,000
Liability Insurance	1,200	acre	1.08	1,296
Office Expense	1,200	acre	75.00	90,000
Rent - Tomato Land	150	acre	250.00	37,500
Sanitation (Toilets)	150	acre	7.50	1,125

UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
Table 6. HOURLY EQUIPMENT COSTS
SAN JOAQUIN VALLEY – 2007

Yr	Description	Actual Hours Used	Capital Recovery	Cash Overhead: Insur-ance	Cash Overhead: Taxes	Operating: Repairs	Operating: Fuel & Lube	Operating: Total Oper.	Total Costs/Hr.
07	130 HP 2WD Tractor	1200	5.72	0.22	0.30	4.15	19.96	24.11	30.35
07	200 HP MFWD Tractor	1600	7.10	0.27	0.37	3.93	30.70	34.63	42.37
07	92 HP 2WD Tractor	1200	3.66	0.14	0.19	2.66	11.95	14.61	18.60
07	Bed Shaper - 3 Row	166	5.76	0.20	0.27	2.62	0.00	2.62	8.85
07	Cultivator-Rolling 3 Row	166	3.70	0.13	0.18	1.69	0.00	1.69	5.70
07	Disk - Offset 26'	166	10.87	0.37	0.52	3.91	0.00	3.91	15.67
07	Disk - Stubble 16'	166	5.70	0.19	0.27	2.06	0.00	2.06	8.22
07	Ditcher - V	164	3.79	0.13	0.18	2.30	0.00	2.30	6.40
07	Fertilizer Injector	121	3.32	0.11	0.15	1.94	0.00	1.94	5.52
07	Flail Shredder 15'	200	5.40	0.17	0.24	6.40	0.00	6.40	12.21
07	Incorporator - 15'	166	9.37	0.29	0.41	5.39	0.00	5.39	15.46
07	Lister - 3 Row 15'	166	2.38	0.08	0.11	1.09	0.00	1.09	3.66
07	Pickup 1/2 ton	283	9.97	0.31	0.43	1.81	8.05	9.86	20.57
07	Saddle Tank 300 gal #1	300	0.90	0.02	0.03	0.65	0.00	0.65	1.60
07	Saddle Tank 300 gal #2	300	0.90	0.02	0.03	0.65	0.00	0.65	1.60
07	Scraper - Drag 10'	166	0.93	0.04	0.05	0.37	0.00	0.37	1.39
07	Spray Boom 20'	150	0.75	0.02	0.03	0.38	0.00	0.38	1.18
07	Spray Boom 25'	150	0.94	0.03	0.04	0.47	0.00	0.47	1.48
07	Subsoiler - 8'	200	4.93	0.16	0.22	2.80	0.00	2.80	8.11
07	Transplanter 3 Row	150	8.51	0.27	0.38	4.27	0.00	4.27	13.43
07	Triplane - 16'	250	6.40	0.22	0.30	3.33	0.00	3.33	10.25
07	Truck Water (2 ton)	200	19.15	0.72	1.01	4.93	7.93	12.86	33.74

UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
Table 7. OPERATIONS WITH EQUIPMENT & MATERIAL INPUTS
San Joaquin Valley - 2007

Operation	Operation Month	Equipment Tractor	Implement	Non-Mach Labor hrs/acre	Material	Broadcast Rate/acre	Unit
Cultural:							
Nutrition: Soil Sampling	Nov	Contract (PCA)			Soil Analysis	0.05	each
Land Prep: Stubble Disk 2X	Nov	200HP MFWD	Stubble Disk				
Land Prep: Chisel/Rip 2X	Nov	200HP MFWD	Subsoiler				
Land Prep: Triplane 2X	Nov	200HP MFWD	Triplane				
Nutrition: Soil Amendment	Nov	130HP 2WD	Fertilizer Spreader		Gypsum	2.00	ton
Land Prep: Disk	Nov	200HP MFWD	Disk Offset 26 ft				
Land Prep: List Beds/Spray Herbicide	Nov	200HP MFWD	Lister		Triflurex	1.00	pt
			2-Saddle Tanks				
			Spray Boom 20 ft				
Land Prep: Shape Beds/Incorporate Herbicide	Nov	200HP MFWD	Bed Shaper 3 Row				
Weed: Spray Beds	Mar	130HP 2WD	2-Saddle Tanks		Roundup	3.00	pt
			Spray Boom 25 ft				
Weed: Cultivate (break surface)	Apr	92HP 2WD	Rolling Cultivator 3 Row				
Nutrition: Fertilize	Apr	130HP 2WD	Fertilizer Injector		8-8-8	1,000.00	lb
			2-Saddle Tanks		Zinc	10.00	lb
Weed: Spray & Incorporate Herbicide	Apr	130HP 2WD	Incorporator 3 Row		Triflurex	1.00	pt
			2-Saddle Tanks		Dual	2.00	pt
Plant: Transplant Seedlings/Fertilize/Insect	Apr	92HP 2WD	Transplanter 3 Row		Seed	6.55	thou
			2-Saddle Tanks		Transplants	6.55	thou
					10-34-00	30.00	lb
					Zinc	0.50	gal
					Humic Acid	1.00	gal
					Admire	10.00	floz
Irrigation: Make Ditches	Apr	130HP 2WD	Ditcher - V				
	June	130HP 2WD	Ditcher - V				
	June	130HP 2WD	Ditcher - V				
Irrigation: Close Ditch	May	130HP 2WD	Scraper - Drag				
	June	130HP 2WD	Scraper - Drag				
	July	130HP 2WD	Scraper - Drag				
Irrigate	Apr			0.50	Water	5.14	acin
	May			1.00	Water	10.28	acin
	June			1.50	Water	15.42	acin
	July			0.50	Water	5.16	acin
Disease: Speck	Apr	130HP 2WD	2-Saddle Tanks		Kocide	2.00	lb
			Spray Boom 25 ft		Dithane	2.00	lb
	May	130HP 2WD	2-Saddle Tanks		Kocide	2.00	lb
			Spray Boom 25 ft		Dithane	2.00	lb
Weed: Cultivate	May	92HP 2WD	Rolling Cultivator 3 Row				
	June	92HP 2WD	Rolling Cultivator 3 Row				
Weed: Hand Hoe	May	Custom/Contract					
Insect: Stinkbug & Mites	May	130HP 2WD	2-Saddle Tanks		Asana	8.00	floz
			Spray Boom 25 ft		Kelthane	1.00	pt
Insect: Stinkbug, Mites, Worms	June	130HP 2WD	2-Saddle Tanks		Asana	8.00	floz
			Spray Boom 25 ft		Agri-Mek	12.00	floz
					Avaunt	3.50	oz
Nutrition: Tissue Samples	June	Contract (PCA)			Analysis	0.05	each
Weed: Layby	June	92HP 2WD	Rolling Cultivator		Dual	1.00	pt
			2-Saddle Tanks				
			Spray Boom 20 ft				
Nutrition: Fertilize (sidedress)	May	130HP 2WD	Fertilizer Injector		UN 32	70.00	lb N
			2-Saddle Tanks				
Nutrition: Fertilize (water run)	June				CAN 17	10.00	lb N

UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION

Table 7. CONTINUED

San Joaquin Valley - 2007

Operation	Operation Month	Equipment Tractor	Implement	Non-Mach Labor hrs/acre	Material	Broadcast Rate/acre	Unit
Harvest: Pick	July	Custom/Contract				18.00	ton
Harvest: Haul to Shed	July	Custom/Contract				18.00	ton
Pack	July	Custom/Contract				1,040.00	box
Water Roads	All	Water Truck					
Field Cleanup: Mow plants	Aug	130HP 2WD	Flail Shredder 15 ft				
Field Cleanup: Disk Crop Residue	Aug	200HP MFWD	Stubble Disk				

WATER USE REQUIREMENTS OF PISTACHIO TREES AND RESPONSE TO WATER STRESS

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One of the most fundamental management decisions California pistachio growers must make involves water management; specifically, when to irrigate and how much water to apply. The objective of good water management is to supply the trees' water needs for optimal tree growth, nut yield, and nut quality. Since water is both scarce and expensive in many major pistachio growing areas, it's important to obtain the most efficient use of water possible in order to maximize bottom-line profits. Just how much water can pistachio trees use? What are the consequences of not meeting this potential evapotranspiration (ET) in terms of tree performance; both short and long term? And what tree processes are most affected by varying levels of plant water stress?

To answer these questions and to broaden our understanding of pistachio plant water relations, a large scale field project was established in a commercial orchard in southern Kings County. This paper reports selected 1984 findings.

DESCRIPTION OF EXPERIMENT

Research Sites

The experiment is being conducted in a 10 year-old planting of "Kerman" of *P. atlantica*. The soil is classified as Wasco sandy loam. This year's work took place in the following three adjacent sites:

Site 1: Well water (no plant water stress) trees under hand move sprinkler irrigation. Crop water use estimates were made on eight trees instrumented with a total of 28 neutron probe access tubes to a depth of 10 ft. This site is described in detail in last year's report and is referred to as the well-watered block.

Site 2: A block of 120 trees that were subjected to severe water stress in 1983 by depriving them of summer irrigation. Half of these trees were equipped with microsprinklers in 1984 and received full ET (their full crop water use requirement). The other half was deprived of summer irrigation for the second consecutive year in 1984.

Site 3: A five acre block, hereafter referred to as the ET rate experiment, that was divided in 1984 into five plots, each approximately 3/4 acre. The objective was to apply water at various percentages of full ET uniformly over the season. Actual applied water rates, corrected for estimated 5% spray evaporation loss, were 0, 25, 50, 70, and 100% of full ET.

This was accomplished by installing a microsprinkler systems equipped with electronic controllers that allowed each plot to be irrigated with the appropriate amount of water. The sprinklers were placed in the tree row midway between trees and wetted a 15 ft diameter circular pattern. The application rate was 10.7 gph. The microsprinklers were managed to apply water twice per week with the duration of application set to apply the desired percentages of full ET. Weekly estimates of full ET were made using preliminary crop coefficient values and pan evaporation data collected in a grass environment nearby.

PROCEDURES

Crop Water Use

A soil water balance approach described in detail in the 1983 annual report was used to evaluate ET. Briefly, frequent monitoring of soil water status in the upper 10 ft of the profile between irrigations was conducted in Site 1. The disappearance of soil water is due to uptake by the trees, evaporation from the soil surface, and deep percolation of water below the deepest soil depth monitored. Using soil hydraulic conductivity data generated during a winter study, we were able to quantify the magnitude of deep percolation during the season. Factoring this out of the soil water balance enabled calculation of orchard water use.

Crop ET data was correlated with pan evaporation to develop crop coefficients (K_p) using the following relation:

$$K_p = ET_c \div E_{pan}$$

where ET_c is the measured crop water use and E_{pan} is USWB Class A pan evaporation measured in a nearby grass environment. Both 1983 and 1984 data were used to develop bimonthly K_p values. Since K_p depends largely on the rate of canopy development, the 1984 data was retarded by one week to normalize the affects of the unusually hot weather.

Photosynthesis

Net CO_2 assimilation rate was measured periodically during the season on individual leaves. Measurements were made with an open gas exchange system. CO_2 was monitored with an ADC Mark III infrared gas analyzer. Leaf temperature, photosynthetic photon flux density (PPFD) and water vapor entering and exiting the leaf chamber also were measured. The leaf chamber consisted of two compartments, enclosing both the upper and lower leaf surfaces simultaneously. Surface area enclosed by the leaf chamber was approximately 7.0 cm^2. Rates of carbon uptake represented the sum of both surfaces. Stomatal conductance measurements made with this system compared favorably to those taken with a LiCor 1600 steady state porometer. All measurements were taken at PPFD's greater than 1.0 $mmol/m^2$-sec.

Trunk Growth

A microdendrometer, an instrument that assesses radial trunk growth and is accurate to more than .001 of an inch, was used to take twice monthly measurements on 30 trees in each experimental plot.

Nut Development

Beginning in early June, 40 nut samples were collected from each of four randomly selected trees in each experimental plot. These nuts were immediately removed to the laboratory where hull (mesocarp), shell (endocarp), and kernel (embryo) weights, both fresh and dry, were determined. After harvest, four trees in each plot (that were left unharvested) were sampled on September 24, October 12, and November 1 to assess both nut development and shell splitting.

Nut Yields and Quality

Commercial harvesting equipment was used to determine gross yields of 40 selected trees in each plot. Selection was based on the trees being immediately surrounded by healthy pistallate trees. Harvest subsamples (200 nuts) were collected from 10 trees in each plot. These nuts were dissected and analyzed for:

1) percentages of blanks (no embryo growth), aborts (evidence of terminated embryo growth), unsplit nuts, and split nuts; and

2) fresh and dry weights of hulls, shells, and kernels.

The harvested split nuts were additionally analyzed to determine relative nut size. Each shell half recovered in the above mentioned analysis was passed through a leaf area meter to determine their cross-sectional areas.

Harvestability

To determine the percentage of total tree nut load that was removed by the mechanical harvest, intensive analysis of the nuts left in the tree after shaking was conducted on eight trees per plot. Immediately after harvest, all remaining nuts were removed by hand and gross weights measured. Detailed examination of nut quality (described above) was conducted on 200 nut samples. With this information, the total number of nuts harvested and remaining in the tree were calculated.

TABLE 1.
Bimonthly values of pistachio tree ET for a normal evaporative demand year in the San Joaquin Valley. Crop coefficients (K_p) were determined from neutron probe data adjusted for deep percolation, and ET estimates made using long term average pan evaporation.

CROP WATER USE (ET) OF PISTACHIO TREES FOR A NORMAL YEAR — Mature, Clean Cultivated Orchards —

	K_p'	ET (in)	ET (in/day)	ET (gal/tree/day)†
April 1-15	0.06	0.17	.011	2
April 16-30	0.35	1.14	.076	14
May 1-15	0.55	2.09	.139	25
May 16-31	0.75	3.41	.213	38
June 1-15	0.88	4.12	.275	49
June 16-30	0.94	4.62	.308	55
July 1-15	0.96	4.72	.315	57
July 16-31	0.96	4.83	.302	54
August 1-15	0.96	4.15	.277	50
August 16-31	0.90	3.70	.231	42
September 1-15	0.80	2.71	.181	33
September 16-30	0.70	2.02	.135	24
October 1-15	0.54	1.26	.084	15
October 16-31	0.40	.76	.048	9
November 1-15	0.28	.36	.024	4

' Crop coefficient for pan evaporation. Current (real time) crop water use can be determined using:

$$ET_{crop} = K_p \times E_{pan}$$

† Based on 17 x 17 ft tree spacing. The following equation can be used to calculate individual tree water use for other spacings:

$$\text{gal/tree/day} = \text{ET (in/day)} \times \text{spacing (ft}^2) \times .622 \text{ (gal/in-ft}^2)$$

RESEARCH RESULTS AND DISCUSSION

Crop Water Use

Crop water use estimates for mature pistachio trees (greater than 60 percent area of the orchard floor shaded by tree canopies midday during the summer) for a normal year are presented in Table 1. These estimates assume clean cultivated conditions; no cover crop or actively growing native weeds or grasses. The crop coefficient (K_p) increases from 0.06 during April 1-15 to a maximum value of 0.96 in early July reflecting rapid canopy development. Maximum K_p values continue through mid August followed by a decline to 0.28 during November 1-15 due to leaf senescence. Using long term average pan evaporation for the San Joaquin Valley and assuming a 17 x 17 ft tree spacing results in crop water use values for a normal year that range from 2 gal/tree/day in early April to 57 gal/tree/day in early July, decreasing to 4 gal/tree/day in early November. Average ET from June through August is 52 gal/tree/day. For the season, Table 1 shows a cumulative crop water use value of 40.1 inches for an average year.

The information presented in Table 1 can be used to schedule irrigations in pistachio orchards. One must be aware, however, that "normal" year seldom occurs, so using long term historical ET data may not reflect conditions during particularly hot or cold seasons. It's best to utilize current (real time) pan evaporation information if it's available. Other indices of evaporative demand, including so-called "reference crop" ET, which is calculated from weather data, can also be used. In many areas of California, various public agencies make these estimates and they are often available to the public. Reference crop values are commonly reported as ET_o (also called ET_r) which approximates the ET of tall grass, or ETP, which approximates the ET of full cover alfalfa. In order to use the K_p data in Table 1 with ET_o reference crop values, it's necessary to multiply the K_p by 1.24, and for ETP, multiply by 1.15.

Regardless of the method used to calculate pistachio ET, it's important to recognize that it represents the amount of water the orchard can use. The amount of water that must be applied to meet this crop water use requirements must be greater than ET to account for losses that invariably result during an irrigation; mainly deep percolation of water below the rootzone and runoff.

One can determine how much extra water is needed with knowledge of the irrigation application efficiency (E_a). This term is commonly used to express how effectively water is applied and is related, in part, to the irrigation method. Consult your local farm advisor for E_a information. Guidelines for using ET information in irrigation management can be found in the following publications: Basic Irrigation Scheduling (UCCE leaflet #21199, $1.00 per copy) and Irrigation Scheduling Guide (available from the State of California, Dept. of Water Resources, Office of Water Conservation, $12.50 per copy).

Seasonal pistachio ET slightly exceeds published water use values for other deciduous trees. For example, ET for almonds is approximately 38 inches for a normal season. However, it must be emphasized that pistachio leaf out, and therefore, crop water use, begins much later than almond. Seasonal pistachio ET is greater because the peak transpiration rates of the tree are remarkably high. This is reflected by the previously mentioned peak K_p value of 0.96 versus 0.75 for almonds. By comparison cotton has a K_p of 1.0 under full cover, non-limiting soil water conditions. Thus, it's clear that pistachio trees can use large amounts of water relative to other crops.

Since both water loss to the atmosphere and CO_2 uptake from the atmosphere occur through leaf structures known as stomata, a linear relationship exists between CO_2 assimilation and stomatal conductance (a measure of stomatal aperture) in most agronomically important plants. Thus, photosynthesis, the process that converts CO_2 to the sugars required to build and maintain plant material, and transpiration are also usually linearly related. Plants limit water loss by controlling stomatal opening. High ET rates, therefore, are usually associated with high rates of photosynthesis. This is

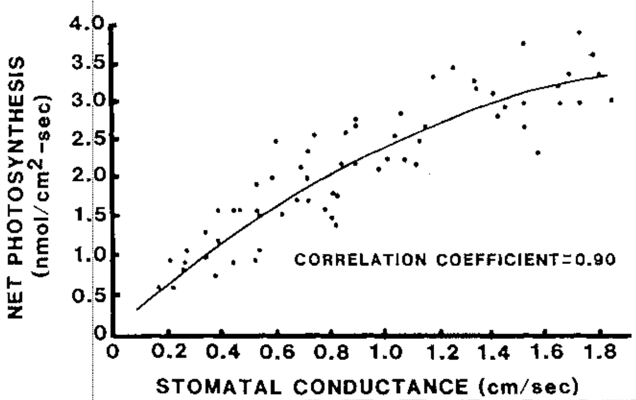

Figure 1.
Relationship between net leaf CO_2 assimilation rate and stomatal conductance. Each data point is the sum of both upper and lower leaf surfaces. Data was taken on July 11, 1984 from ET rate plot. Curve is the best fit second order regression.

normally reflected by rapid plant growth, either vegetative, reproductive, or both. But pistachio trees are notoriously slow growing. Do high water use rates correspond with high levels of CO_2 assimilation in pistachio?

Figure 1 shows the relationship between net photosynthesis and stomatal conductance. Note that these parameters are not linearly related, but that the mathematical description of best fit is curvilinear. This results in progressively smaller increases in photosynthesis for each incremental increase in stomatal conductance. Again, if one assumes that transpiration is controlled largely by stomatal aperture, this suggests that CO_2 assimilation rate increases do not keep pace with increases in water use. In other words, high water use rates are not manifested by equally high photosynthetic rates. Apparently, the law of diminishing returns applies to the relationship between CO_2 uptake and water use. This raises the question of whether it's necessary for pistachio trees to consume the large amounts of water they are capable of using, or can optimal orchard growth and productivity be achieved at something less than full ET. The following results of the ET rate experiment and subsequent monitoring of this block should provide the answer.

First Year Effects of Different ET Levels

The influence of various ET rates on current season nut quality and harvestability are shown in Figure 2. It manifests striking differences in the relative percentages of split and unsplit nuts. Split nuts accounted for 13.6, 44.9, 73.4, 74.8, and 77.9 percent of the total number of nuts (the sum of those harvested and left in the tree) for the 0, 25, 50, 70%, and full ET levels, respectively. On the other hand, non-splits made up 56.6, 36.8, 8.8, 7.0, and 10.9 of the tree nut load in the respective ET plots. Clearly, severe water stress, imposed under the 0 and 25% ET regimes, delayed the biochemical processes necessary for shell splitting in large percentages of the crop. These processes were only mildly affected at 50 and 70% ET.

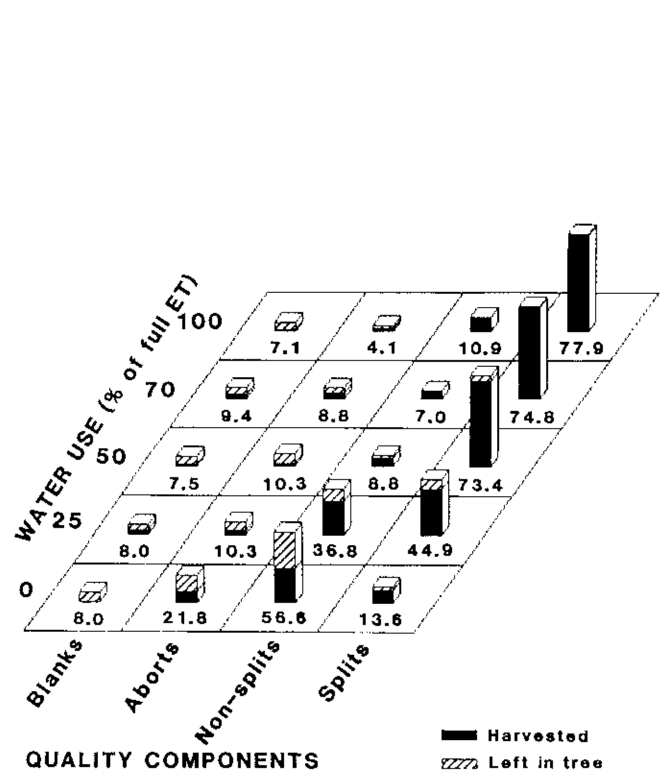

Figure 2.
Affect of ET levels on current season nut quality and harvestability. Column heights and numbers in grid squares represent total tree nut load percentages (both harvested and left in tree after shaking) of each quality component for a particular ET rate. Data are averages of 200 nut samples from each of 10 trees per plot.

Figure 2 shows that blanking was similar in all irrigation regimes. However, embryo abortion was appreciably greater at the 0 ET level, accounting for 21.8% of the total nut load. The relative amount of the nut load that remained in the tree after mechanical shaking, illustrated in Figure 2 as the cross-hatched areas of the columns, was noticeably lower at 50% or less of full ET.

Nut harvest component data, expressed on a dry weight basis per tree, is presented in Figure 3. It shows that *total* harvest weights generally increased with increasing ET levels. The increase in harvest weights of *dry in-shell splits* is even more dramatic; 2.5, 12.3, 19.8, 28.4, and 31.7 lbs/tree at 0, 25, 50, 70 and 100% ET, respectively. This corresponds to decreases in harvested dry in-shell splits relative to full ET of 92.1, 61.2, 37.5, 10.4% for the respective ascending ET levels.

Figure 4 shows the sensitivity of four tree performance parameters to the different ET levels in terms of relative performance under full ET. In addition to harvest yields of dry in-shell splits, the performance parameters are:

1) Radial trunk growth from March 1 through October 31;

2) Nut biomass; the total dry weight of the tree nut load, both harvested and left in the tree after shaking, regardless of nut quality; and

3) Nut harvestability; the percentage of the tree nut load removed by shaking.

The figure illustrates that the two most sensitive parameters to plant water stress are yield (dry in-shell splits) and trunk growth. For example, at 50% ET, radial trunk growth was 51.2% that of full ET, whereas nut biomass and harvestability were 68.3 and 88.1%, respectively, of values obtained under full ET. Even at 70% ET, trunk growth was 12.2% less than full ET. This is not surprising in that expansive growth has been shown to be one of the most sensitive plant processes to water stress. Reduced tree growth can have at least two important negative ramifications. First, it will slow the rate of development of young trees and, therefore, decrease yields in the early years of an orchard and lengthen the time for orchard maturity. Additionally, reduced shoot growth in trees of all sizes may decrease the number of fruiting positions and/or cluster size, again reducing yield.

Harvestability increased with increasing ET. Figure 4 shows that 51.5, 77.2, 88.1, and 96.6% of full ET harvested percentage came off the tree at 0, 25, 50, and 70% ET, respectively. Again, the plant processes involved in forming the nut abscission layer were adversely affected by water stress.

The least sensitive performance parameter shown in Figure 4 was biomass accumulation in the nuts. This verifies our observation of previous seasons that the developing nuts are strong photosynthate sinks. Indeed, in terms of harvested split nuts on a dry weight per nut basis, virtually no differences existed at 50, 70, and 100% ET. Corresponding nut weights (sum of kernel and shell) were 1.17, 1.17, and 1.18 gms/nut, respectively. This information is presented in Table 2, in addition to relative nut size data.

On a per nut basis, harvested split nuts in the 0 ET plot weighed 28.8% less than those under full ET (.84 versus 1.18 gms/nut). Equivalent data at 25% ET reveals a 9.3% lower nut weight (1.07 versus 1.18 gms/nut). Lower nut weights resulted from smaller nut size, rather than incomplete filling. Besides visual observations during nut dissections, this conclusion is supported by the shell cross-sectional areas relative to full ET shown in Table 2; (76.2 and 94.0% for the 0 and 25% ET levels, respectively). Even though it's been reported that ultimate shell size is attained in May, shell enlargement apparently was reduced by water stress at these lower ET levels even during the early part of the season. This is not surprising since shell enlargement is an expansive growth process and, therefore, quite sensitive to even mild plant water stress.

Second Year Affects of Severe Water Stress

Depriving selected trees in Site 2 of summer irrigation for a second consecutive year allowed the affects of continuing severe plant water stress on nut development and tree performance to be observed. Figure 5 illustrates the impact on nut quality. Data for a single year of severe water stress (the 1984 0 ET plot) and non-stressed conditions (the 1984 100% ET plot) are included for comparison.

Surprisingly, nut quality was quite similar for both one and two years of severe stress. Indeed, the total tree nut load percentages of split nuts were almost identical; 13.6% for one year and 13.8% after two years. The same is true for unsplit nuts; 56.6 and 56.1% after one and two years, respectively. Nut abortion was relatively high in both years (21.8% in year one and 17% in year two). Blanking, which Figure 2 showed was negligibly affected by current season water stress, was a relatively high 13.1% of the tree nut load after two years of stress. This indicates a possible carry-over effect of water stress on the processes responsible for blanking.

While nut quality was little changed between one and two years of severe water stress, other aspects of tree performance did show marked differences. Figure 6 presents data on trunk growth, biomass accumulation in the nuts, harvestability, and yield (dry in-shell splits) for one and two years severe stress and one year stress followed by a return to full ET conditions (no stress). By far, the parameter most influenced was trunk growth where the second year stressed trees had only 13.4% as much growth as well-watered trees. One year of stress followed by adequate irrigation resulted in nearly a complete recovery in the rate of trunk growth (87.3% of the growth of well-watered trees).

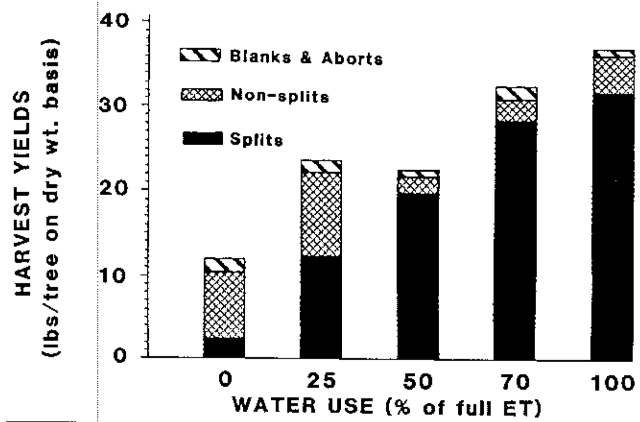

Figure 3.
Harvest yield components on a dry weight basis for different ET levels. Data are averages of 40 trees per plot.

TABLE 2.
Nut component dry weights (shell and kernel) and relative sizes of harvested, split nuts for different ET levels. Data represent averages of 200 nuts collected from each of 10 trees.

Water Use Rate (% full ET)	Shell	Embryo	Total	Relative Shell Size* (%)
		gm/nut		
0	.40	.44	.84	76.2
25	.50	.57	1.07	94.0
50	.54	.63	1.17	99.2
70	.55	.62	1.17	99.0
100	.55	.63	1.18	—

*Values are expressed as percentages of shell cross sectional areas relative to value obtained under full ET.

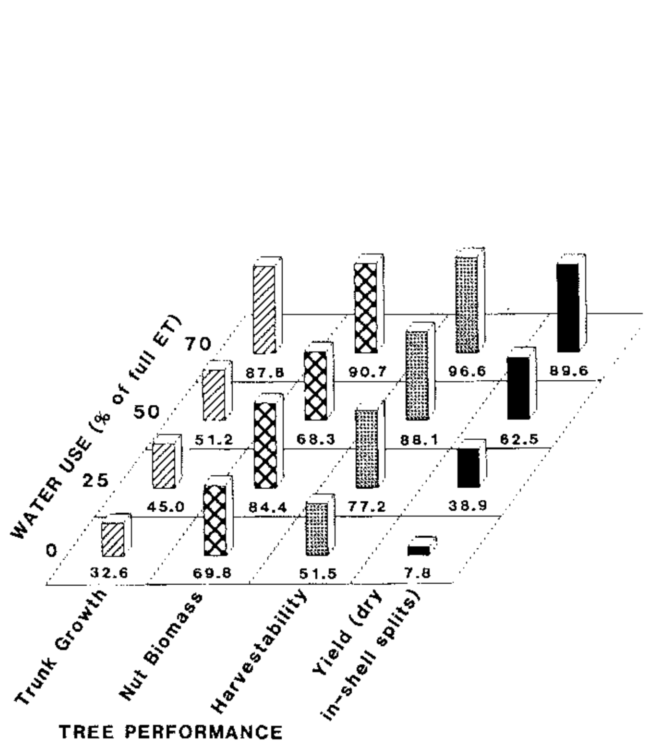

Figure 4.
Relative influence of ET levels on selected current season tree performance parameters. Column heights and numbers in grid squares represent percentages of values obtained under full ET. Performance parameters are described in detail in the text.

A return to non-stressed conditions did not result in dry in-shell split yield (52.8% of 100% ET yield) recovering as much as trunk growth. This was due to a greater percentage of both aborted nuts and blanks, as well as to slightly less nut splitting and harvestability. In fact, blank nuts totalled 14.8% of the total tree nut load compared to 7.1% under full ET. This, again, indicates that carryover effects of severe water stress on blank nut production, regardless of the irrigation conditions following the stress.

The remarkable strength of the nuts as photosynthate sinks is shown in the nut biomass data in Figure 5. The total tree nut weight, without regard to quality, was only marginally less after two years stress compared to one year. There was actually a greater total nut weight after one year stress than after a return to full ET. Besides the ability of the stressed nut to accumulate dry matter, this was due mainly to greater blanking and nut abortion in the year following one year of severe stress.

Harvestability after two years stress actually improved relative to one year, which at first appears to contradict previously mentioned data. This phenomenon was due to the breakage of complete rachises during tree shaking resulting in whole nut clusters being harvested rather than individual nuts. The hulls of these nuts remained tightly bound to the shells.

It should be emphasized that since no summer irrigation was applied to the severe stress plots, what little water that was used came primarily from winter rainfall. Water use totalled only 9.9 inches for the trees stressed for two consecutive years and 3.0 inches for the single year of stress. Water use estimates were made by monitoring to a soil depth of 20 ft in these plots. Figure 7 shows the seasonal soil water depletion pattern for the second year stress plot. The trees extracted water throughout the entire monitored profile. However, the pressence of significant depletion in the 17 to 20 ft layer suggests that additional water was extracted below 20 ft. The magnitude of this unmeasured water use is unknown.

CONCLUSIONS

Pistachio trees can use large amounts of water. Midsummer ET (June through August) under normal conditions averages 52 gal/tree/day for clean cultivated mature trees on a 17 x 17 ft spacing. Seasonal crop water use is 40.1 inches for a normal year in the San Joaquin Valley. Both peak and seasonal ET exceeds that of other deciduous trees.

Field measurements of CO_2 assimilation from trees under different irrigation regimes showed that net leaf photosynthesis and stomatal conductance (an indice of stomatal opening and water use) are curvilinearly related. This differs from the linear relationship of most crops and suggests that carbohydrate production increases do not keep pace with increases in ET. Further study is needed to examine whether this indicates that sustained satisfactory orchard productivity can be obtained at crop water use rates less than full ET.

Under differential water application amounts, harvest yields (dry in-shell splits) increased with increasing ET. Tree water use of less than 50% ET (20 inches for a normal year) resulted in appreciably reduced shell splitting. A less severe impact was observed on harvestability. Water stress, no matter how severe, only negligibly affected the current season blank nut production. Embryo abortion was greater only at the lowest ET level.

Progressively greater water stress appears to affect the following current season tree performance parameters in descending order of severity (i.e., most sensitive listed first): yield (dry in-shell splits), radial trunk growth, harvestability, and biomass accumulation in the nuts. The size of the harvested split nuts was reduced by relatively severe water stress (0 and 25% ET) due to the severity of shell enlargement to early season stress during May.

Second year affects of continued severe water stress (no summer irrigation) on nut quality, yield, and harvestability were little changed from the first year results. It's remarkable that trees under two years of severe stress (9.9 inches of total ET) survived, let alone produced nuts, although leaf size and canopy density were reduced. Also, premature leaf yellowing followed by partial defoliation occurred. Trunk growth also decreased dramatically.

Trees severely stressed for one year and then irrigated the following season at full ET approached complete recovery with respect to growth and harvestability. However, yield (dry in-shell splits) and biomass accumulation in the nuts only partially recovered due to a greater amount of nut abortion and blanking. This indicates some carryover effects of severe water stress on blanking, regardless of irrigation levels in the season following the stress.

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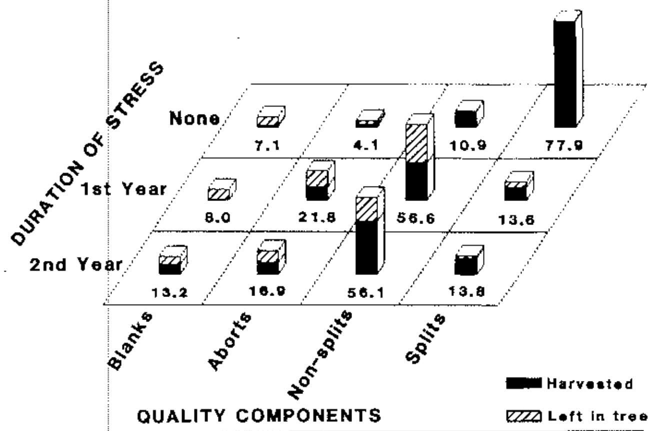

Figure 5.
Severe water stress affects (no summer irrigation) for one and two years on nut quality and harvestability. Full ET values are shown for comparison. Column heights and numbers in grid squares represent total tree nut load percentages (both harvested and left in tree after shaking) of each quality component for a particular ET rate. Data are averages of 200 nut samples from each of 10 trees per plot.

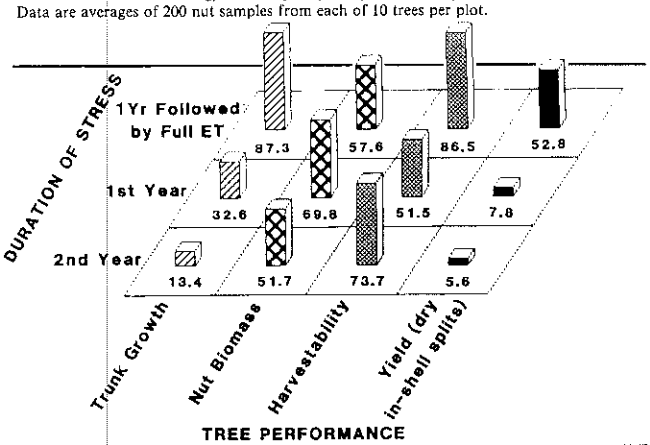

Figure 6.
Effects of severe stress for one year, two years, and one year followed by full ET on selected current season tree performance parameters. Column heights and numbers in grid squares represent percentages of values obtained under full ET. Performance parameters are described in detail in the text.

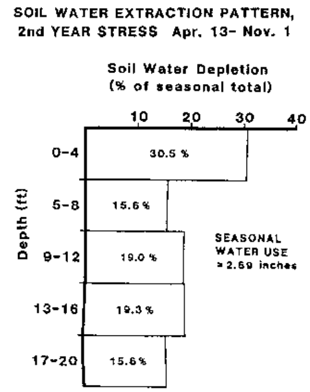

Figure 7.
Pattern of seasonal soil water extraction during 1984 by trees deprived of summer irrigation for two seasons beginning in 1983.

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University of California
UC Drought Management

Almonds

Summary of University of California research on irrigation management for almond trees under drought conditions

For maximum growth, yield, crop quality and orchard longevity almonds trees should be supplied with water to meet their full water requirement. There are some disease concerns with hull rot under full water conditions which can be addressed with moderate water stress during hull split. (Teviotdale et al. 2001) If water availability is limited, growers can react by applying irrigation water when trees are most sensitive to stress and by taking measures to minimize water losses that occur during irrigation events. Supplying less water than the trees can potentially use reduces soil water availability, causes tree water deficits, and reduces transpiration. Cover crops, depending on the coverage and the time of the season in which they are grown can increase the orchard water use by up to 30% . Cover crops should be removed when water is in limited supply (Prichard et al. 1989).

Water deficits affect almond orchards not only in the year in which stress occurs, but also in the following seasons. Generally, nut size is reduced in the first season of significant water stress. Because water stress also reduces vegetative growth and potentially decreases productivity per unit canopy volume, nut load can be reduced in subsequent years (Lampinen et al. 2007). Recent research indicates some stages of almond fruit growth are more sensitive to water stress than others. Understanding these stages permits growers to withhold water while minimizing damage to trees and to current and subsequent crops.

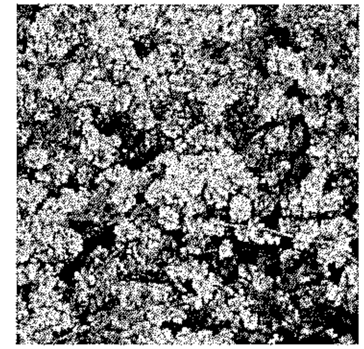
Early season stress

Water stress affects more tree and crop development processes during the early season - from leaf out through shoot growth and development of terminal and lateral buds. During this period, rapid vegetative development is necessary for canopy development and fruiting positions for the following season. (Goldhamer et al. 2006) (Prichard et al. 1994) In addition, orchard water use during this time is low compared to summer demand, reducing potential water savings from an early-season deficit irrigation strategy.

Fruit growth and developement

Nuts undergo a rapid growth phase early in the fruit growth and development period and are sensitive to water deficits during this time. However, trees can tolerate drought stress fairly well during the two months prior to harvest, allowing for the successful use of deficit irrigation strategies during this period. (Shackel et al. 2004). Providing less than the full water requirement to cause moderate water stress during this period, will have little influence on kernel weight. However, severe water stress in the months leading up to hull split will reduce kernel weight and significantly reduce hull spliting. A one-inch irrigation prior to hull split will mitigate the water stress impacts and will improve hull split and reduce the number of hull-tights. (Prichard et al. 1994) If drip irrigation is used, possibly less irrigation can provide the same benefit, but this has not been proven in the field.

Post harvest stress



The effect of water deficits during the postharvest period are substantially affected by 1) pre harvest water deficits and 2) the quantity of water use over the remainder of the season. Bud differentiation can continue through mid-September. Moderate stress during this period will have little effect on subsequent year's nut numbers, but severe stress during bud differentiation has been found to dramatically reduce fruit set the following spring (Goldhamer et al. 2006). In early harvest (early August) districts, particularly with early varieties, more of the high water use season remains after harvest. This increases the necessity for postharvest irrigation. Later harvest (north State) districts and later varieties have a slightly shorter postharvest period which occurs at a time of lower crop water demand. These factors reduce the chance of moderate water deficits causing bud differentiation problems (Prichard et al. 1994).

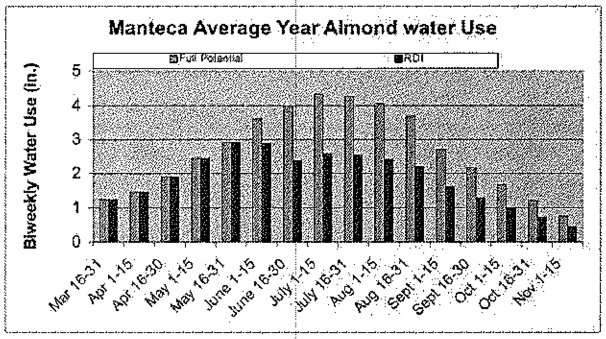
Tree response to postharvest stress can be influenced by the type of irrigation system used, and the previous irrigation management. Low volume systems with limited soil water reserves can result in severe water deficits very quickly after irrigation cut off. In the southern San Joaquin Valley where harvest is earlier than in the north, or with drought-sensitive varieties, postharvest irrigation is a necessity. Deep rooted, surface irrigated trees may have enough pre-harvest deep moisture remaining to carry them through the critical period of bud differentiation. This all depends on the irrigation management occurring pre-harvest.

• Developing a Deficit Irrigation Strategy

Crop Water Use

Almond water use begins when the leaves develop and shoot growth begins. Concurrent with canopy development, the climatic demand increases, driven by longer days and higher temperatures and low humidities as the season progresses. Both of these factors result in a seasonal water use starting at a low level, peaking in mid-season and falling as season ends. Sources of water available to trees include: soil-stored moisture (including frost protection water applications if the root zone is less than field capacity when applications are made), any in-season rainfall absorbed by the soil, and applied irrigation water. These all combine to determine the total seasonal water available to the orchard.

Mature conventionally spaced almond trees in the Southern Sacramento Valley can use about 41- 44 inches of water in an average year of unrestricted water use. High-density orchards, long pruned orchards, or those with a cover crop can have even higher use. . Soil moisture monitoring demonstrations in more than 40 almond orchards in Kern County indicate that seasonal water use in the southern San Joaquin Valley may be as high as 50 - 54 inches (Sanden 2007). Figure 1 shows a typical water use pattern for fully irrigated and a deficit irrigation regime for almond in the Manteca area.



The moderately deficit irrigated orchard used (in a combination of soil supplied and irrigation water) 28 inches of water or about 34 % less than the full potential orchard.

Water Deficits

Water deficits occur when the climatic water demand exceeds the water absorbed by the roots. As the soil becomes depleted of readily available moisture, water uptake by the roots lags behind water use causing plant stress in the mid to late afternoon. This minor crop water deficit has little effect on the crop yield. However, as soil water becomes increasingly difficult to extract water stress increases. One way to measure "tree stress" is to use a portable pressure chamber to measure "midday stem water potential". To use this technique a few leaves from representative trees are first covered with an opaque plastic bag while still on the tree. The covers need to remain on the leaves at least 10 minutes after which they are detached and the the water potential measured using the pressure chamber (Fulton et al. 2001). The pressure chamber measures the amount of pressure needed to force water out of the leaf petiole, indicating trees water status. http://fruitsandnuts.ucdavis.edu/General_Management/The_Pressure_Chamber,_aka_The_Bomb.htm

A Moderate Water Stress Strategy

From the previous discussion it can be concluded that tree water use from leaf out through mid June should not be compromised. From mid June through harvest, reductions up to 50% of full water use have been successfully used to reduce orchard water use with only minimal reductions in kernel weight. It is important to supply the trees with water near hull split to avoid hull-tights.

There are various approaches growers can take to manage limited water supplies depending on what types of irrigations scheduling tools interest or are available to them. A simple method is to reduce irrigation run time or lengthen irrigation intervals to obtain the desired percentage of irrigation reduction in applied water. In a four-year study investigating pre-harvest, post-harvest, and uniform deficit irrigation for the entire season, the best results were achieved when water applications occurred at a uniform deficit rate across the season relative to full potential crop ET. The uniform deficit rate does not mean a uniform irrigation amount across the season (e.g. 1.5 inches each week), but rather a uniform (e.g. 85%) reduction of full ET for each period. Deficit irrigation rates of 55%, 70%, and 85% were tested with the 70% and 85% irrigation reduction treatments showing little yield loss compared to the full ET treatment. (Goldhamer et al. 2006) The 70% and 85% uniform across the season deficit treatments experienced little early season stress, likely because stored soil moisture supplemented the applied irrigations.

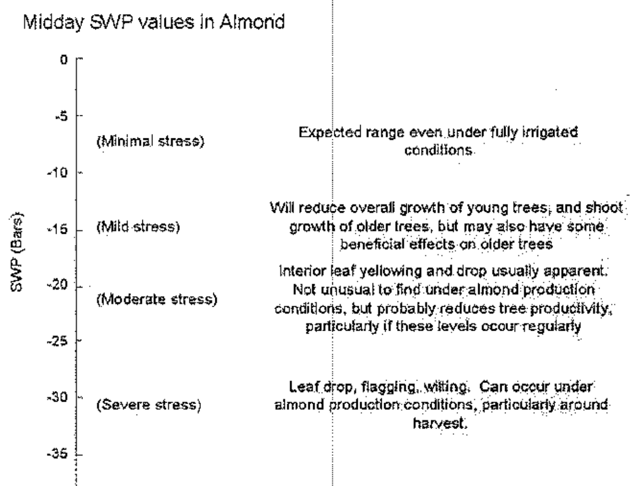
Another approach that is likely an improvement over the approach outlined above is to schedule irrigations using periodic pressure chamber readings and irrigate when midday stem water potential reaches a pre-determined threshold stress level (see Figure below). This method effectively extends the irrigation interval, but the interval is determined by tree water status rather than the calendar. Irrigations should be in the volume of a normal set as performed with a full irrigation regime. In a deficit irrigation study conducted on mature almond in the Manteca, CA a just prior to irrigation threshold value of -20 to -22 bars midday stem water potential beginning in June resulted in 34% less tree water consumption and no significant influence on yield for the 4-year measurement period. (Prichard et al. 1994) It should be noted that a reduction in vegetative growth was measured in this treatment, indicating that use of this threshold for a longer-term strategy (more than 4 years) may reduce yields by reducing nut numbers. The impacts of stress on a developing tree canopy is much more detrimental as opposed to the impacts on a canopy that has already reached it's full volume.

A More Severe Water Stress Strategy

A more severe strategy that reduces seasonal tree water use by 50% requires that stress be imposed early as well as mid to late season. Using this strategy, irrigations in April and May are withheld until trees reach a midday stem water potential of -12 to -14 bars. Using conventional sprinklers, a normal set time is used. If lighter applications are made, more water is lost by evaporation. From June 1st through hull split, midday stem water potential values should be allowed to reach -20 to -22 bars just prior to irrigation. This strategy will require a pre-harvest irrigation of about 2 inches with sprinklers-less with micros and drip--to ensure good hull split. Note: this strategy reduces water use significantly but also reduces nut weight the year it is used and the nut number in succeeding years. In the Manteca trial discussed above, it took 2 years of full irrigation for trees to recover. (Prichard et al. 1996)

A "Staying Alive" Drought Strategy

Less is known about this strategy since it is a rarely used option. However, based on past drought conditions, trees may be kept alive with about a foot of applied water. This strategy does not consider growth and yield-just tree survival. This strategy is best conducted using a micro-irrigation system which maximizes water distribution and minimizes evaporative losses from irrigation. Using this strategy no irrigation is applied until water potential reaches -16 bars from leaf out through the end of May. Monitor stem water potential until the threshold is reached again then repeat the cycle. After June 1st, and for the rest of the season allow the stress to climb to -25 bars prior to irrigation. As a guide, try to just retain the leaves on the tree. Good luck, as this is only a guide. Remember that following this severe deficit strategy, it will take at least 2 years of full irrigation for the trees to recover to normal yields.



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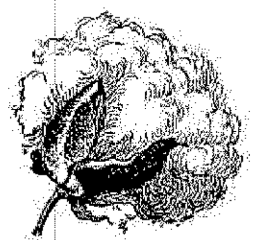
UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION

2003

SAMPLE COSTS TO PRODUCE

COTTON

ACALA VARIETY



30-INCH ROW
SAN JOAQUIN VALLEY

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UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION

SAMPLE COST TO PRODUCE COTTON – ACALA VARIETY
SAN JOAQUIN VALLEY - 2003

CONTENTS

INTRODUCTION

Sample costs for SJV Acala cotton production in the San Joaquin Valley (SJV) are presented in this study. This study is intended as a guide only, and can be used to make production decisions, determine potential returns, prepare budgets and evaluate production loans. Practices described are based on production procedures considered typical for growing conditions in the San Joaquin Valley region. Sample costs given for labor, materials, equipment and contract services are based on current figures. Some costs and practices used in this study may not be applicable to your situation. A blank *Your Cost* column is provided to enter your actual costs on Tables 1 and 2.

For an explanation of calculations used for the study refer to the Assumptions or call the Department of Agricultural and Resource Economics, University of California- Davis, (530) 752-3589 or the UC Cooperative Extension Farm Advisor in the county of interest.

Sample cost and return studies for many commodities are available and can be requested through the Department of Agricultural and Resource Economics, UC Davis. Current studies can be downloaded from the department website at http://coststudies.ucdavis.edu or obtained from selected county UC Cooperative Extension offices.

ASSUMPTIONS

The following assumptions give background information relevant to the values shown in Tables 1 to 6 and pertain to sample costs for producing SJV Acala cotton in the San Joaquin Valley region. This study also assumes the grower will partially participate in the government crop programs under the Farm Security and Rural Investment Act of 2002. **The costs figures are based on typical cultural practices for 30-inch rows used by farmers in the San Joaquin Valley and are not University of California recommendations.** Some farming practices described may not be used during every production year or on every farm, while some operations not described may be needed. *The use of trade names in this report does not constitute an endorsement or recommendation by the University of California nor is any criticism implied by omission of other similar products.*

Land. The farm consists of 1,500 acres of non-contiguous land, which includes 750 acres rented and planted to cotton. The remaining acres are planted to other field and row crops including processing tomatoes, corn, wheat, alfalfa, barley, onions, garlic, carrots, lettuce and broccoli. Land rental costs are described in the "Cash Overhead Costs" section of the text and tables. The owner manages the farm.

Production Operating Costs

Tables 1-3 show the costs associated with ground preparation, planting, growing, and harvesting cotton. Land preparation is done from October to March and the crop is harvested in October and November. The crop year in this study is November to November.

Land Preparation. The ground is ripped or subsoiled in two passes, 2 to 3 feet deep, to break up compaction, which affects root penetration and water infiltration. In this study subsoiling is done once every three years and one-third of the cost is allocated to the crop each year. The ground is then disced twice with a stubble disc to break up large clods and smooth the surface. The ground is again disced twice with a finish (offset disc) – once while applying an herbicide and once to further incorporate the herbicide and smooth the surface. Afterwards the beds are listed.

Row Spacing. In this study, cotton is planted on 30-inch beds. Forty-inch row spacing constitutes the majority of the cotton acreage in the San Joaquin Valley. However, 30-inch row spacing acreage is increasing in the San Joaquin Valley and is an alternative to 38 or 40-inch row cotton. Some field trials in the 1980's and 1990's done by University of CA researchers indicated that yields could increase as much as 7% by changing from 38 or 40 inch row spacing to 30 inch rows. In the research evaluations, these yield improvements were achieved without increases in water or fertilizer requirements. The yield improvements were most commonly observed in the northern part of the SJV, with less consistent results or even no reported yield increases in UC studies in other parts of the San Joaquin Valley. Carefully consider local experience with 30-inch cotton and examine several row spacing options to determine the best system and likely impacts on yields and production costs. Refer to the study *Sample Costs To Produce Cotton, 40-Inch Row, San Joaquin Valley, 2003* for cost comparisons.

Planting. An Acala cotton variety is seeded at a rate of 18.0 pounds per acre during April. Cotton is planted using an eight-row or 10-row planter. Seed populations range from 35,000 to as much as 85,000 per acre, with an optimum stand of 40,000 to 55,000 plants per acre. Yields are generally not significantly affected

by plant populations ranging from about 30,000 to 60,000 plants per acre, but average final plant population targets for most growers and varieties in 30-inch row cotton production areas are generally in the 45,000 to 60,000 plants per acre range. The seed cost includes the San Joaquin Valley Cotton Board assessment. (See Assessment Section).

Irrigation. In this study a water cost of $60 per acre-foot is used. Grower applied water ranges from 2.0 to 3.5 acre feet based upon soil type, irrigation method, water application uniformity, crop rooting depth in some soils, evaporation, and runoff. Based on current information it is estimated that 2.5 acre-feet of water is applied during the growing season for cotton in this region, though this amount is dependent upon soil and climatic factors. Water cost for irrigation represents a combination of district water and pumped water. Price per acre-foot for water will vary by grower depending on the irrigation district and its limits on available water, increased costs and competition for water, and increased energy costs for running irrigation wells where groundwater is available as a backup water supply. Water costs depending on irrigation district or pumping variables can range from $20 per acre-foot to over $140 per acre-foot for late season irrigation in water-short districts.

Most UC and USDA research has indicated that total water use in crops planted in 30-inch rows is similar to that in 38 or 40-inch rows. In this cost study example, the rented land has an irrigation system adequate to irrigate the total cotton acreage. The irrigation system cost, therefore, is included as part of the land rental cost, which is under the category later described as "Cash Overhead Costs". A ditch-based furrow irrigation system is assumed for this example.

Fertilization. Nitrogen is the primary nutrient applied to cotton throughout the growing season. UN-32 (32-0-0) is sidedressed at a rate of 150 pounds of N per acre during the month of May. A fertilizer applicator is rented from the fertilizer dealer. Thirty pounds of N as UN-32 is water run in July. The labor cost for applying the water run N is included in the irrigation costs. A foliar application of potassium nitrate (13-0-45) at 1.3 pounds of N per acre is mixed with the growth regulator and applied in late-June or July. The desirability of this foliar nutrient application is largely dependent upon the yield potential of the plant and relative plant vigor (i.e. the better the yield potential on the plant, or the lower the vigor, the more likely that a favorable, cost-effective response will be obtained with foliar nutrient applications).

Cotton is very responsive to nitrogen, but excessive applications can cause rank or vegetative growth and lead to increased pest problems, poor defoliation, lower yields, and nitrate leaching. If the crop rotation includes heavily-fertilized vegetable crops or alfalfa, or if dairy waste or manure applications are common practices on individual fields, residual soil nitrogen and even potassium may be high. These situations would then present an opportunity to reduce input costs and lower applied nitrogen, resulting in fewer problems with excessive growth and leaching losses.

Pest Management. The pesticides, rates, and cultural practices mentioned in this cost study are listed in the *UC IPM Pest Management Guidelines, Cotton* **Pesticides mentioned in this study are not recommendations, but those commonly used in the region.** For information and pesticide use permits, contact the local county Agricultural Commissioner's office. For information on other pesticides available, pest identification, monitoring, and management, visit the UC IPM website at www.ipm.ucdavis.edu. **Pest control costs can vary considerably each year depending upon local conditions and pests in any given year. Ranges can be as dramatic as $50 per acre for one year and $200 the next.**

Pest Control Adviser (PCA). Written recommendations are required for many pesticides and are made by licensed pest control advisers. In addition the PCA or an Agronomist consultant will monitor the field for agronomic problems including pests and nutrition. Growers may hire private PCA's or receive the service as part of a service agreement with an agricultural chemical and fertilizer company. In this study, a fee is allocated for a PCA.

Insects. In this study, pest management is for mites, aphids, and lygus. An aerial application of Zephyr is made in May for mite control, Warrior insecticide in June for lygus control, and Provado insecticide in July for aphid control. Monitoring of insect populations is necessary to determine if and when to treat the crop. There may be some assumptions that the more closed crop leaf canopy would impact potential for pest problems in the narrower 30-inch row spacing as compared to 38 or 40 inch spacings, but there are no definitive studies done in California on which to base differences in insect or mite population pressures or control costs. For this reason, the assumptions regarding pest populations, management thresholds and practices, and control costs are assumed to be the same in 30-inch row spacing as with 40-inch spacing.

Lygus bugs feed on the squares (flower buds) and small fruit (bolls). Damaged squares will usually drop off while damaged bolls at a minimum may have stained lint and damaged seeds, or can be lost if damaged when bolls are less than 10 to 12 days in age past the flowering stage. In cases where there are repeated or sustained infestations of lygus bugs, it is not uncommon to need more than the assumed one insecticide application for lygus bug control to protect yields.

Aphids cause physical damage to the leaves and/or contaminate the lint with their honeydew production. Also, their feeding may reduce the carbohydrates needed for boll maturation, resulting in yield loss. Mites feeding on the leaves reduce plant vigor and result in extensive defoliation.

Cost estimates do not include insecticide applications for beet armyworm control. In some years and/or locations, beet armyworm can develop into populations capable of causing significant yield reductions, and their control will cause an additional expense.

Cost estimates also do not include control measures for silverleaf whitefly, which in some years can be a major late-season pest in parts of the southern and even central San Joaquin Valley. Silverleaf whitefly has the potential to cause sticky cotton and reduce the value of cotton lint (fiber). Insect growth regulators and insecticides are available to aid in control, but costs are highly variable by location and timing of infestations, choice of control measures, and number of applications required. Similarly, if aphid problems continue into the late-season when bolls open and cotton lint is exposed to aphid honeydew, another insecticide application in addition to the assumed one application may be required to prevent sticky cotton.

Weeds. Beginning in November, a pre-emergent herbicide (Treflan) is applied and incorporated in the fields at discing. This application will control many early season annual broadleaves and grasses. An "over-the-top" herbicide, Staple in this study, for control of broadleaves is sprayed in May. Cultivations also begin in late April (depending upon planting date) and continue until the end of June. A total of four cultivations are done in this study, using rolling cultivators. The first cultivation is made prior to planting in March and the remaining three are done from April to June. Hand hoeing is done in June and a post-directed herbicide/layby treatment is made in June with Caparol.

Weed management practices and options will differ if a transgenic, herbicide-resistant cotton variety is grown. Some of the cultural practice assumptions, herbicide materials used, and differences in production cost estimates are shown in the separate cost study entitled "*2003 Sample Costs to Produce Cotton – Acala, 40-Inch Rows, Transgenic Herbicide-Resistant Varieties*".

Growth Regulator & Defoliation. A plant growth regulator (mepiquat chloride, also known as "Pix" or other trade names) is applied with the foliar nutrients near first bloom in late June through mid-July. There is little conclusive data available to indicate that growth regulator use typically differs much in 30-inch row spacing cotton as compared with 40-inch cotton, although a large number of field studies have resulted in some differences in recommendations for application rates based on plant monitoring information and expected yield responses.

Harvest aid chemicals, also called by the group name "defoliants", are applied in September and/or October. Typical harvest aid applications include two application timings, with materials such as Prep and Ginstar applied in the first application, and a second application 14 days or more later with materials such as Defol and Gramoxone Max.

Plant growth regulators control excessive vegetative growth and promote a balance between vegetative and reproductive growth. This results in a more uniform boll set for once over harvesting. Defoliants are applied prior to picking to aid harvest by causing the leaves to drop. Defoliation is essential for efficient mechanical picking. It reduces the amount of trash collected with the cotton, and reduces staining of the lint.

Harvest. The farm in this study owns two five-row cotton harvesters and two module builders. The cotton is dumped from the harvester directly into the module builder that presses loose seed cotton into a dense and economical unit for transportation to the gin. A tractor and tractor driver monitor each module. Two laborers maintain the area – cleaning cotton off the ground, placing a tarp on the finished module, etc. – during the harvest operations. It is important to note that unless growers have pickers with moveable heads, the choice to produce cotton on 30-inch or 40-inch rows dictates that at least some harvest equipment (pickers) be set up and available to operate at that row-spacing. At least on the short-term basis of day to day operations, pickers set up for 30-inch rows will be used only for picking 30-inch row fields.

Custom Operators costs range around $85 per acre for picking and building module. Growers may choose to own cotton pickers and module builders, purchased either new or used, or hire a custom harvester to perform the harvest. Many factors are important in deciding which harvesting option a grower uses. The decision to invest in cotton harvesting equipment requires consideration of differences in production practices and equipment requirements for all of the crops in rotation as well as the direct cost of the harvesting equipment. These factors and appropriate method of analysis are discussed by Blank et al, (1992). Though their report specifically addresses hay harvesting the same principles and methodology can be used with cotton harvesting.

Yields. The crop yield used in this study is 1,340 pounds of lint and 2,378 pounds of seed per acre for San Joaquin Valley cotton. The yield is based on an assumed yield of 1,250 lbs of lint per acre for 40-inch row cotton, with the assumption that yield under 30-inch row production will be increased by approximately 7%.

The increase is based on field trials mostly in the 1980's and early 1990's, showing that lint yields could increase about 7% by changing from 40-inch to 30-inch row spacing without any increase in water or fertilizer needs. These yield improvements were most commonly observed in the northern SJV, with less consistent results in other areas of the SJV.

If your experience or assumptions are that yields with 30-inch rows for cotton are similar to those with 38 or 40-inch rows, use the cost and return calculations in Table 6 of both this study and the cost study for 40 inch cotton to compare values at the same yields.

Returns. An estimated price of a $0.70 per pound of lint is used to calculate returns above several levels of cost. Some cooperative cotton gins pay growers as much as $5 to $25 per bale for seed credit above grower ginning costs, but is not a regular practice. Table 6 shows grower returns for varying yields. In this study, all cotton acres are assumed to be covered by program payments. In reality, however, maximum payment limitations may leave some acres uncovered, which will reduce income.

Revenue from federal government programs. A typical cotton farm may receive revenue from three major payment programs under the Farm Security and Rural Investment Act of 2002 (FSRI).

Direct Payments in the FSRI Act pay a predetermined amount per unit of established crop-specific farm program base, but do not require growing the program crop or any other crop. Since these payments are essentially unrelated to cotton production itself, this revenue is not appropriately associated with costs and is not included in the "cotton" revenue in Table 2.

Counter-Cyclical Payment program payments are designed to payout the difference between the legislated target price for the commodity and the national average market price for that marketing year. However, as with the direct payment program, these counter-cyclical payments are made on the basis of historical base and do not require any program crop production. Therefore it is inappropriate to associate these payments with the production of cotton and they are not included in the "cotton" revenue presented in Table 2.

Marketing Loan and Loan Deficiency Payment programs make payments to farmers equal to the difference between the loan rate and the loan repayment rate for each pound of cotton received. Because these payments are tied directly to cotton production, they are included as a part of the revenue from cotton farming in Table 2. The loan rate for cotton is scheduled to be $0.52 per pound for the next six years. The loan program in essence pays the grower the difference between this loan rate and the applicable adjusted world price (AWP), which currently is fluctuating around $0.37. Based on past price relationships, the assumed cotton price of $0.70 used for the analysis below is consistent with a marketing loan benefit of about $0.15 per pound. The grower receives the benefit, regardless of the price he receives for his cotton. Therefore, for the hypothetical farm in this study the revenue is $.85 per pound of production.

Transportation. Transportation costs are based on roundtrip distances from the field to the gin. Most gins within a close radius of the field do not charge because the cost is included in the ginning fee. Longer hauls (over 40 miles round trip) will have a hauling charge. Hauling companies may also have a surcharge for modules less than a minimum weight.

Ginning. Commercial cotton gins normally keep cottonseed and give growers a credit to cover ginning and transportation costs so most growers do not see a ginning charge. In this study, ginning fees are covered by the seed credit and are not included as a line-item cost. Some gins especially cooperatives may return to the grower a net difference of $5 to $25 per bale between the seed value and ginning costs

Cotton gins charge growers for compressing lint into universal density (UD) bales for shipping. In this study a fee of $7.00 per bale is charged which includes hydraulic compressing, a sample for the merchant, and a loading charge. Some ginners also charge a $1 invoicing fee, but the fee is not included in this study.

Assessments. Most assessments are collected by the gin or handler and deducted from the growers' gross returns. Both mandatory and voluntary assessments are discussed below.

USDA-HVI. The USDA levies a fee for High Volume Instrumentation (HVI) classing. This determines the marketing classification cotton grade. Growers are mandated with a $1.55 per bale fee.

Cotton Incorporated. Cotton Incorporated was created by a federal marketing order and is overseen by the Cotton Board. Cotton Inc. provides funds for industry research and promotion and currently requires growers to pay $1.00 per bale plus a supplemental 0.5% lint assessment on the current gross value lint returns per bale. The supplemental assessment in this study is $1.75 per bale ($0.70 x .005 x 500 lb bale).

Pink Bollworm Project. The California State Department of Food and Agriculture (CDFA) manages and enforces the Pink Bollworm Project. This program, which through detection and legislated postharvest practices, controls pink bollworm in the San Joaquin Valley and other cotton growing districts in the state. The Pink Bollworm Project maintains several control districts to administer the program. Under the project growers are assessed a fee only if cotton is ginned within a project district. CDFA has a current charge of $2.00 per bale.

National Cotton Council. The National Cotton Council, a voluntary organization, collects an assessment to provide lobbying, advocacy, and public relations for the cotton industry at the national level. The current assessment rate paid by growers is $0.45 per bale.

California Cotton Growers And Ginners Association. The California Cotton Growers And Ginners Association assists California cotton growers in advocating their position in the legislature. The growers are charged $0.15 per bale and the ginners are charged $0.15 per bale. Participation in this organization is voluntary.

San Joaquin Valley Cotton Board. The board reviews test program data and approves variety releases. Most of the money goes to the University of California for variety evaluation. The assessment is added to the seed price. The current assessment paid by the grower is $3.75 per planting seed hundredweight. Revenue collected by the board in 2001 averaged $0.85 per producing acre.

Pickup. Two pickups – one-half ton and three-quarter ton – are used on the ranch. It is assumed that each pickup travels 4,998 miles each year for total ranch use.

Labor. Basic hourly wages for workers are $9.51 per hour for machine operators and $8.23 per hour for non-machine workers. Adding 34% for the employers share of federal and state payroll taxes and other benefits raises the total labor costs to $12.74 per hour for machine operators and $11.02 per hour non-machine labor. The labor for operations involving machinery is 20% higher than the operation time to account for the additional time involved in equipment set up, moving, maintenance and repair.

Equipment Operating Costs. Repair costs are based on purchase price, annual hours of use, total hours of life, and repair coefficients formulated by the American Society of Agricultural Engineers (ASAE). Fuel and lubrication costs are also determined by ASAE equations based on maximum PTO horsepower, and fuel type. Prices for on-farm delivery of diesel and gasoline are $1.11 and $1.58 per gallon, respectively. The cost includes a 2.25% sales tax (effective September 2001) on diesel fuel and 7.25% sales tax on gasoline. Gasoline also includes federal and state excise tax, which can be refunded for on-farm use when filing your income tax. The fuel, lube, and repair cost per acre for each operation in Table 1 is determined by multiplying the total hourly operating cost in Table 5 for each piece of equipment used for the selected operation by the hours per acre. Tractor time is 10% higher than implement time for a given operation to account for setup, travel and down time.

Interest on Operating Capital. Interest on operating capital is based on cash production costs and is calculated monthly until harvest at a nominal rate of 7.14% per year. A nominal interest rate is the typical market cost of borrowed funds. The interest cost of post harvest operations is discounted back to the last harvest month using a negative interest charge.

Risk. The risks associated with crop production should not be minimized. While this study makes every effort to model a production system based on typical, real world practices, it cannot fully represent financial, agronomic and market risks, which affect the profitability and economic viability.

Cash Overhead Costs

Cash overhead consists of various cash expenses paid out during the year that are assigned to the whole farm and not to a particular operation. These costs include property taxes, interest on operating capital, office expense, liability and property insurance, equipment repairs, and management.

Property Taxes. Counties charge a base property tax rate of 1% on the assessed value of the property. In some counties special assessment districts exist and charge additional taxes on property including equipment, buildings, and improvements. For this study, county taxes are calculated as 1% of the average value of the property. Average value equals new cost plus salvage value divided by 2 on a per acre basis.

Insurance. Insurance for farm investments varies depending on the assets included and the amount of coverage. Property insurance provides coverage for property loss and is charged at 0.676% of the average value of the assets over their useful life. Liability insurance covers accidents on the farm and costs $1,246 for the entire farm.

Office Expense. Office and business expenses are estimated at $30 per acre. These expenses include office supplies, telephones, bookkeeping, accounting, legal fees, shop, and office utilities, and miscellaneous administrative charges.

Land Rent. The land is rented on a cash basis for $125 per acre. The agreement includes the use of the irrigation system on the property.

Investment Repairs. Annual maintenance is calculated as 2% of the purchase price.

Non-Cash Overhead Costs

Non-cash overhead is calculated as the capital recovery cost for equipment and other farm investments.

Capital Recovery Costs. Capital recovery cost is the annual depreciation and interest costs for a capital investment. It is the amount of money required each year to recover the difference between the purchase price and salvage value (unrecovered capital). It is equivalent to the annual payment on a loan for the investment with the down payment equal to the discounted salvage value. This is a more complex method of calculating ownership costs than straight-line depreciation and opportunity costs, but more accurately represents the annual costs of ownership because it takes the time value of money into account (Boehlje and Eidman). The formula for the calculation of the annual capital recovery costs is ((Purchase Price – Salvage Value) x Capital Recovery Factor) + (Salvage Value x Interest Rate).

Salvage Value. Salvage value is an estimate of the remaining value of an investment at the end of its useful life. For farm machinery (tractors and implements) the remaining value is a percentage of the new cost of the investment (Boehlje and Eidman). The percent remaining value is calculated from equations developed by the American Society of Agricultural Engineers (ASAE) based on equipment type and years of life. The life in years is estimated by dividing the wear out life, as given by ASAE, by the annual hours of use in this operation. For other investments including irrigation systems, buildings, and miscellaneous equipment, the value at the end of its useful life is zero. The salvage value for equipment and investments are shown in Table 5.

Capital Recovery Factor. Capital recovery factor is the amortization factor or annual payment whose present value at compound interest is 1. The amortization factor is a table that corresponds to the interest rate used and the life of the machine.

Interest Rate. The interest rate of 6.25% used to calculate capital recovery cost is the USDA-ERS's ten-year average of California's agricultural sector long-run rate of return to production assets from current income. It is used to reflect the long–term realized rate of return to these specialized resources that can only be used effectively in the agriculture sector.

Land. The grower owns 750 acres of row-crop land valued at $3,300 per acre. Values for land with relatively secure irrigation water supplies in the region range from $700 per acre to $5,000, depending upon location and soil condition. The site for the cotton in this study is rented land enrolled in the government subsidy program.

Building. The buildings are metal buildings erected on a cement slab and cover approximately 2,400 square feet.

Tools. This includes shop tools, hand tools, and miscellaneous field tools. The number is not based upon an actual or average inventory.

Fuel Tanks. Diesel and gasoline fuel tanks with electric pumps are set up in a cement containment pad that meets federal, state, and county regulations.

Equipment. Farm equipment is purchased new or used, but the study shows the current purchase price for new equipment. The new purchase price is adjusted to 60% to indicate a mix of new and used equipment. Annual ownership costs for equipment and other investments are shown in Table 4. Equipment costs are composed of three parts: non-cash overhead, cash overhead, and operating costs. Both of the overhead factors have been discussed in previous sections. The operating costs consist of repairs, fuel, and lubrication and are discussed under operating costs.

Table Values. Due to rounding, the totals may be slightly different from the sum of the components.

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UC COOPERATIVE EXTENSION

Table 1. COSTS PER ACRE to PRODUCE ACALA COTTON

SAN JOAQUIN VALLEY - 2003

	Operation	Cash and Labor Cost per acre					
Operation	Time (Hrs/A)	Labor Cost	Fuel, Lube & Repairs	Material Cost	Custom/ Rent	Total Cost	Your Cost
Cultural:							
Rip Fields 1X/3Yrs	0.27	4	7	0	0	11	
Primary Discing 2X	0.25	4	7	0	0	11	
Apply Herbicide	0.20	3	4	5	0	12	
Incorporate Herbicide w/Disc	0.14	2	3	0	0	5	
List Beds	0.07	1	1	0	0	2	
Make Ditch	0.06	1	1	0	0	2	
Irrigate (labor includes water run UN32)	5.00	55	0	150	0	205	
Fertilizer - Water Run UN32	0.00	0	0	8	0	8	
Close Ditch	0.06	1	1	0	0	2	
Cultivate – Preplant	0.10	2	1	0	0	3	
Plant	0.12	2	2	24	0	28	
Uncap Beds	0.08	1	1	0	0	2	
Cultivate - 3X	0.31	5	4	0	0	9	
Fertilizer - Sidedress UN32	0.14	2	2	39	2	45	
Weed Control - Over-The-Top Spray	0.20	3	2	18	0	24	
Insect Control - Mites	0.00	0	0	36	8	43	
Weed Control - Hand Hoe	5.00	55	0	0	0	55	
Weed Control - Post Directed/Layby	0.20	3	2	16	0	21	
Insect Control - Lygus	0.00	0	0	9	8	16	
Insect Control - Aphids	0.00	0	0	16	8	24	
Apply Growth Regulator & KNO3	0.00	0	0	11	8	18	
Defoliate Cotton 2X	0.00	0	0	43	15	58	
PCA	0.00	0	0	0	12	12	
Pickup Truck Use	0.44	7	2	0	0	9	
TOTAL CULTURAL COSTS	12.64	151	40	375	59	624	
Harvest:							
Harvest	0.30	5	20	0	0	24	
Build Module and Haul	0.30	8	4	0	0	12	
TOTAL HARVEST COSTS	0.60	13	24	0	0	36	
Gin:							
Gin (paid by seed credit)	0.00	0	0	0	0	0	
Gin Compression Charge	0.00	0	0	0	19	19	
TOTAL GIN COSTS	0.00	0	0	0	19	19	
Assessment:							
Assessments	0.00	0	0	18	0	18	
TOTAL ASSESSMENT COSTS	0.00	0	0	18	0	18	
Postharvest:							
Chop Stalks	0.10	2	2	0	0	4	
Disc Residue - 2X	0.24	4	8	0	0	11	
TOTAL POSTHARVEST COSTS	0.34	5	9	0	0	14	
Interest on operating capital @ 7.14%						24	
TOTAL OPERATING COSTS/ACRE		168	73	392	78	736	
Cash Overhead:							
Land Rent Cotton						125	
Office Expense						30	
Liability Insurance						1	
Property Taxes						5	
Property Insurance						4	
Investment Repairs						3	
TOTAL CASH OVERHEAD COSTS						167	
TOTAL CASH COSTS/ACRE						904	

UC COOPERATIVE EXTENSION

Table 1. continued

Non-Cash Overhead:	Per Producing Acre	Annual Cost Capital Recovery	Total Costs	Your Costs
Buildings	40	3	3	
Fuel Tanks	4	0	0	
Shop/Field Tools	8	1	1	
Siphon Pipes 3"x 90"	5	1	1	
Service Truck 2-Ton	84	10	10	
Equipment	741	91	91	
TOTAL NON-CASH OVERHEAD COSTS	882	106	106	
TOTAL COSTS/ACRE			1,010	

UC COOPERATIVE EXTENSION

Table 2. COSTS AND RETURNS PER ACRE to PRODUCE ACALA COTTON

SAN JOAQUIN VALLEY - 2003

	Quantity/ Acre	Unit	Price or Cost/Unit	Value or Cost/Acre	Your Cost
GROSS RETURNS					
Lint	1,340.00	lb	0.70	938	
LDP	1,340.00	lb	0.15	201	
TOTAL GROSS RETURNS				1,139	
OPERATING COSTS					
Herbicide:					
Treflan HFP	1.50	pt	3.50	5	
Staple	0.38	floz	48.23	18	
Caparol	1.50	qt	10.57	16	
Water:					
Water	30.00	acin	5.00	150	
Seed:					
Seed	18.00	lb	1.35	24	
Insecticide:					
Zephyr	6.00	floz	6.00	36	
Warrior	3.20	oz	2.73	9	
Provado	3.75	oz	4.27	16	
Growth Regulator:					
Pix	0.50	pt	15.16	8	
Fertilizer:					
13-0-46 Solution Grade	10.00	lb	0.32	3	
UN32	180.00	lb N	0.26	47	
Defoliant:					
Prep	2.00	pt	6.24	12	
Ginstar	8.00	floz	1.83	15	
Defol 6	1.00	gal	10.00	10	
Gramoxone Max	1.00	pt	5.78	6	
Assessment:					
Cotton Incorporated	2.68	bale	1.00	3	
Cotton Incorporated Supplemental	2.68	bale	1.75	5	
California Ginners and Cotton Growers	2.68	bale	0.15	0	
National Cotton Council	2.68	bale	0.45	1	
Pink Bollworm Project	2.68	bale	2.00	5	
USDA Classing Fee	2.68	bale	1.40	4	
Rent:					
Fertilizer Applicator	1.00	acre	2.00	2.00	
Custom:					
Air Application	6.00	acre	7.50	45	
Gin Compression Charge	2.68	bale	7.00	19	
Gin Charge (Paid by seed credit)	2.68	bale	0.00	0	
Contract:					
PCA/Consultant Fee	1.00	acre	12	12	
Labor (machine)	4.31	hrs	12.74	55	
Labor (non-machine)	10.30	hrs	11.02	114	
Fuel - Diesel	32.56	gal	1.11	36	
Lube				5	
Machinery repair				32	
Interest on operating capital @ 7.14%				24	
TOTAL OPERATING COSTS/ACRE				736	
NET RETURNS ABOVE OPERATING COSTS				403	

UC COOPERATIVE EXTENSION

Table 2. continued

	Value or Cost/Acre	Your Costs
CASH OVERHEAD COSTS:		
Land Rent Cotton	125	
Office Expense	30	
Liability Insurance	1	
Property Taxes	5	
Property Insurance	3	
Investment Repairs	3	
TOTAL CASH OVERHEAD COSTS/ACRE	167	
TOTAL CASH COSTS/ACRE	904	
NON-CASH OVERHEAD COSTS (Capital Recovery)		
Buildings 2,400sqft	3	
Fuel Tanks 2-500 gal	0	
Shop/Field Tools	1	
Siphon Pipes 3"x 90"	1	
Service Truck 2-Ton	10	
Equipment	91	
TOTAL NON-CASH OVERHEAD COSTS/ACRE	106	
TOTAL COSTS/ACRE	1,010	
NET RETURNS ABOVE TOTAL COSTS	129	

UC COOPERATIVE EXTENSION
Table 3. MONTHLY CASH COSTS PER ACRE to PRODUCE ACALA COTTON
SAN JOAQUIN VALLEY - 2003

Beginning NOV 02 / Ending NOV 03	NOV 02	DEC 02	JAN 03	FEB 03	MAR 03	APR 03	MAY 03	JUN 03	JUL 03	AUG 03	SEP 03	OCT 03	NOV 03	TOTAL
Cultural:														
Rip Fields 1X/3Yrs	11													11
Primary Discing 2X	11													11
Weed: Apply Herbicide	12													12
Incorporate Herbicide	5													5
List Beds	2													2
Make Ditch				1			1		1					2
Irrigate				51				38	77	39				205
Close Ditch				1				1			1			2
Cultivate 4X					3	3	3	3						11
Plant						28								28
Uncap Beds						2								2
Fertilize - Sidedress UN32							45							45
Weed Control - Over-The-Top							24							24
Insect Control - Mites							43						5	43
Weed Control - Hand Hoe								55					5	55
Weed Control - Direct/Layby								21						21
Insect Control - Lygus								16					5	16
Insect Control - Aphids									24				4	24
Apply Growth Regulator & Fertilizer									18					18
Fertilizer - Water Run UN32									8					8
Defoliate Cotton 2X												58		58
PCA	1	1	1	1	1	1	1	1	1	1	1	1	1	12
Pickup Truck Use	1	1	1	1	1	1	1	1	1	1	1	1		9
TOTAL CULTURAL COSTS	43	2	2	54	4	35	117	136	129	40	3	60	1	624
Harvest:														
Harvest													24	24
Build Module													12	12
Gin Compression Charge													19	19
TOTAL HARVEST COSTS													55	55
Assessment:														
Assessments													18	18
TOTAL ASSESSMENT COSTS													18	18
Postharvest:														
Chop Stalks													3	3
Disc Residue - 2X													11	11
TOTAL POSTHARVEST COSTS													14	14
Interest on operating capital	0	0	0	1	1	1	2	2	3	3	3	4	4	24
TOTAL OPERATING COSTS/ACRE	43	2	2	55	5	36	119	138	132	44	6	63	93	736
TOTAL OPERATING COSTS/LB	0.03	0.00	0.00	0.04	0.00	0.03	0.09	0.10	0.10	0.03	0.00	0.05	0.07	0.55
OVERHEAD:														
Land Rent Cotton													125	125
Office Expense	2	2	2	2	2	2	2	2	2	2	2	2	2	30
Liability Insurance			1											1
Property Taxes			3						3					5
Property Insurance						2						2		4
Investment Repairs	0	0	0	0	0	0	0	0	0	0	0	0		3
TOTAL CASH OVERHEAD COSTS	3	3	6	3	3	4	3	3	5	3	3	4	127	167
TOTAL CASH COSTS/ACRE	46	4	8	57	8	40	121	141	137	46	8	68	220	904
TOTAL CASH COSTS/LB	0.03	0.00	0.01	0.04	0.01	0.03	0.09	0.10	0.10	0.03	0.01	0.05	0.16	0.67

UC COOPERATIVE EXTENSION
Table 4. WHOLE FARM ANNUAL EQUIPMENT, INVESTMENT, and BUSINESS OVERHEAD
SAN JOAQUIN VALLEY - 2003

ANNUAL EQUIPMENT COSTS

					Cash Overhead		
Yr Description	Price	Yrs Life	Salvage Value	Capital Recovery	Insur-ance	Taxes	Total
03 105 hp 2wd Tractor	62,000	10	18,314	7,151	271	402	7,824
03 105 hp 4wd Tractor	75,000	10	22,154	8,650	328	486	9,464
03 150 hp 4wd Tractor	110,000	10	32,492	12,687	482	712	13,881
03 230 hp track-type	154,000	10	45,489	17,761	674	997	19,433
03 Cultivator Rolling 20' #1	6,800	5	2,215	1,234	30	45	1,310
03 Cultivator Rolling 20' #2	6,800	5	2,215	1,234	30	45	1,310
03 Disc - Finish 21'	19,595	12	2,714	2,211	75	112	2,398
03 Disc-Stubble 18' #1	42,000	10	7,427	5,217	167	247	5,632
03 Disc-Stubble 18' #2	42,000	10	7,427	5,217	167	247	5,632
03 Ditcher - 8'	7,800	15	749	785	29	43	856
03 Harvester 5-Row #1	275,000	10	51,873	33,918	1,105	1,634	36,657
03 Harvester 5-Row #2	275,000	10	51,873	33,918	1,105	1,634	36,657
03 Lister 6 Row 20'	5,500	12	762	621	21	31	673
03 Module Builder #1	24,000	10	4,244	2,981	95	141	3,218
03 Module Builder #2	24,000	10	4,244	2,981	95	141	3,218
03 Mower-Flail 20'	14,445	15	1,387	1,453	54	79	1,586
03 Pickup - 1/2 Ton	24,000	5	10,756	3,838	117	174	4,129
03 Pickup - 3/4 Ton	28,000	5	12,549	4,477	137	203	4,817
03 Planter-8 Row 20'	15,015	15	1,442	1,511	56	82	1,648
03 Rear Blade - 10'	2,581	18	172	237	9	14	261
03 Saddle Tank 300gal #1	3,218	5	1,048	584	14	21	620
03 Saddle Tank 300gal #2	3,218	5	1,048	584	14	21	620
03 Spray Boom 20' #1	913	3	380	224	4	6	235
03 Spray Boom 20' #2	913	3	380	224	4	6	235
03 Subsoiler 10'	14,800	10	2,617	1,838	59	87	1,984
03 Uncapper-8 row 20'	8,500	10	1,503	1,056	34	50	1,140
TOTAL	1,245,098		287,474	152,592	5,180	7,663	165,438
60% of New Cost *	747,059		172,484	91,556	3,108	4,598	99,262

ANNUAL INVESTMENT COSTS

					Cash Overhead			
Description	Price	Yrs Life	Salvage Value	Capital Recovery	Insur-ance	Taxes	Repairs	Total
Buildings 2,400 sqft	60,000	30		4,476	203	300	1,200	6,179
Fuel Tanks 2-500 gal	6,514	20	651	562	24	36	130	752
Service Truck 2-Ton	125,500	10	25,000	15,379	509	752	2,510	19,151
Shop/Field Tools	12,000	15	1,200	1,205	45	66	240	1,556
Siphon Pipes 200 3"x 90"	8,024	10		1,103	27	40	160	1,330
TOTAL INVESTMENT	212,038		26,851	22,726	807	1,194	4,240	28,968

ANNUAL BUSINESS OVERHEAD COSTS

Description	Units/ Farm	Unit	Price/ Unit	Total Cost
Land Rent Cotton	750	acre	125.00	93,750
Liability Insurance	1,500	acre	0.83	1,246
Office Expense	1,500	acre	30.00	45,000

UC COOPERATIVE EXTENSION
Table 5. HOURLY EQUIPMENT COSTS
SAN JOAQUIN VALLEY - 2003

		COSTS PER HOUR							
	Actual		Cash Overhead		Operating				
	Hours	Capital	Insur-			Fuel &	Total	Total
Yr Description	Used	Recovery	ance	Taxes	Repairs	Lube	Oper.	Costs/Hr.
03 105 hp 2wd Tractor	1,178.60	3.64	0.14	0.20	2.81	7.78	10.59	14.58
03 105 hp 4wd Tractor	1,599.60	3.24	0.12	0.18	1.94	7.78	9.72	13.27
03 150 hp 4wd Tractor	1,730.90	4.40	0.17	0.25	2.86	11.11	13.97	18.78
03 230 hp track-type	1,600.20	6.66	0.25	0.37	4.00	17.04	21.04	28.32
03 Cultivator Rolling 20' #1	231.80	3.20	0.08	0.12	0.65	0.00	0.65	4.05
03 Cultivator Rolling 20' #2	154.50	4.43	0.11	0.16	0.65	0.00	0.65	5.35
03 Disc - Finish 21'	273.20	4.85	0.17	0.24	3.11	0.00	3.11	8.37
03 Disc-Stubble 18' #1	199.50	15.69	0.50	0.74	6.79	0.00	6.79	23.73
03 Disc-Stubble 18' #2	200.00	15.65	0.50	0.74	6.79	0.00	6.79	23.69
03 Ditcher - 8'	130.00	3.62	0.13	0.20	1.19	0.00	1.19	5.14
03 Harvester 5-Row #1	124.60	163.36	5.32	7.87	39.97	19.26	59.23	235.78
03 Harvester 5-Row #2	124.60	163.36	5.32	7.87	39.97	19.26	59.23	235.78
03 Lister 8 Row 20'	165.70	2.25	0.08	0.11	1.10	0.00	1.10	3.54
03 Module Builder #1	113.20	15.80	0.51	0.75	3.25	0.00	3.25	20.30
03 Module Builder #2	113.20	15.80	0.51	0.75	3.25	0.00	3.25	20.30
03 Mower-Flail 20'	130.20	6.69	0.25	0.36	6.33	0.00	6.33	13.64
03 Pickup - 1/2 Ton	399.60	5.76	0.18	0.26	1.78	2.55	4.33	10.53
03 Pickup - 3/4 Ton	399.60	6.72	0.21	0.30	2.08	2.55	4.63	11.86
03 Planter-8 Row 20'	132.70	6.83	0.25	0.37	2.96	0.00	2.96	10.41
03 Rear Blade - 10'	160.00	0.89	0.03	0.05	0.37	0.00	0.37	1.35
03 Saddle Tank 300gal #1	400.00	0.88	0.02	0.03	0.02	0.00	0.02	0.95
03 Saddle Tank 300gal #2	400.00	0.88	0.02	0.03	0.02	0.00	0.02	0.95
03 Spray Boom 20' #1	500.00	0.27	0.01	0.01	0.25	0.00	0.25	0.53
03 Spray Boom 20' #2	500.00	0.27	0.01	0.01	0.25	0.00	0.25	0.53
03 Subsoiler 10'	200.00	5.52	0.18	0.26	3.34	0.00	3.34	9.29
03 Uncapper-8 row 20'	60.70	10.43	0.33	0.49	1.73	0.00	1.73	12.98

UC COOPERATIVE EXTENSION
Table 6. RANGING ANALYSIS
SAN JOAQUIN VALLEY - 2003

COSTS PER ACRE AT VARYING YIELDS TO PRODUCE ACALA COTTON

	LINT YIELD (lbs/acre)							
	750	1,000	1,250	**1,340**	1,500	1,750	2,000	2,250
OPERATING COSTS/ACRE								
Cultural Cost	624	624	624	**624**	624	624	624	624
Harvest Cost	22	28	34	**37**	41	47	53	59
Assessment Cost	10	14	17	**18**	20	24	27	30
Ginning/Compression Cost	10	14	18	**19**	21	25	28	32
Postharvest Cost	14	14	14	**14**	14	14	14	14
Interest on operating capital	24	24	24	**24**	25	25	25	25
TOTAL OPERATING COSTS/ACRE	704	718	731	**736**	745	759	771	784
TOTAL OPERATING COSTS/LB	0.94	0.72	0.58	**0.55**	0.50	0.43	0.39	0.35
CASH OVERHEAD COSTS/ACRE	167	167	167	**167**	167	167	167	167
TOTAL CASH COSTS/ACRE	871	885	898	**904**	912	926	938	951
TOTAL CASH COSTS/LB	1.16	0.89	0.72	**0.67**	0.61	0.53	0.47	0.42
NON-CASH OVERHEAD COSTS/ACRE	106	106	106	**106**	106	106	106	106
TOTAL COSTS/ACRE	977	991	1,004	**1,009**	1,018	1,032	1,044	1,057
TOTAL COSTS/LB	1.30	0.99	0.80	**0.75**	0.68	0.59	0.52	0.47

UC COOPERATIVE EXTENSION
Table 6, continued

NET RETURNS PER ACRE **ABOVE OPERATING COSTS** FOR ACALA COTTON

PRICE ($/lb)		LINT YIELD (lbs/acre)							
Lint		750	1,000	1,250	**1,340**	1,500	1,750	2,000	2,250
	LDP	750	1,000	1,250	**1,340**	1,500	1,750	2,000	2,250
0.55	0.15	-179	-18	144	202	305	466	629	791
0.60	0.15	-142	32	207	269	380	554	729	904
0.65	0.15	-104	82	269	336	455	641	829	1,016
0.70	**0.15**	-67	132	332	403	530	729	929	1,129
0.75	0.15	-29	182	394	470	605	816	1,029	1,241
0.80	0.15	9	232	457	537	680	904	1,129	1,354
0.85	0.15	46	282	519	604	755	991	1,229	1,466

NET RETURNS PER ACRE **ABOVE CASH COST** FOR ACALA COTTON

PRICE ($/lb)		LINT YIELD (lbs/acre)							
Lint		750	1,000	1,250	**1,340**	1,500	1,750	2,000	2,250
	LDP	750	1,000	1,250	**1,340**	1,500	1,750	2,000	2,250
0.55	0.15	-346	-185	-23	35	138	299	462	624
0.60	0.15	-309	-135	40	102	213	387	562	737
0.65	0.15	-271	-85	102	169	288	474	662	849
0.70	**0.15**	-234	-35	165	236	363	562	762	962
0.75	0.15	-196	15	227	303	438	649	862	1,074
0.80	0.15	-159	65	290	370	513	737	962	1,187
0.85	0.15	-121	115	352	437	588	824	1,062	1,299

NET RETURNS PER ACRE **ABOVE TOTAL COST** FOR ACALA COTTON

PRICE ($/lb)		LINT YIELD (lbs/acre)							
Lint		750	1,000	1,250	**1,340**	1,500	1,750	2,000	2,250
	LDP	750	1,000	1,250	**1,340**	1,500	1,750	2,000	2,250
0.55	0.15	-452	-291	-129	-71	32	193	356	518
0.60	0.15	-415	-241	-67	-4	107	281	456	631
0.65	0.15	-377	-191	-4	63	182	368	556	743
0.70	**0.15**	-340	-141	59	130	257	456	656	856
0.75	0.15	-302	-91	121	197	332	543	756	968
0.80	0.15	-265	-41	184	264	407	631	856	1,081
0.85	0.15	-227	9	246	331	482	718	956	1,193

LDP = Loan Deficiency Payment
BOLD = Data used in study